SAN FRANCISCO WASTEWATER PROGRAM

CITY AND COUNTY OF SAN FRANCISCO

Survey of Sport Shellfishing Potential in San Francisco Bay, in Southern San Francisco and Northern San Mateo Counties

FINAL REPORT

DECEMBER 1978

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Prepared by:

James E. Sutton
1839 Ninth St.
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December 1978

E R R A T A

Page	Correction
25	Figure 2 - Sample locations A-1-1 & A-1-2 are transposed
40	Under Section 4 - Change '57,000 Tapes' to read '57,600 Tapes'
43	2nd paragraph, 2nd sentence - Change 'Callianasa' to read 'Callianassa'
70	Last line - Change 'fout' to read 'four'

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Prepared for the City and County of San Francisco
Wastewater Program under EPA Grant Number
C-06-1399-010 and DPW Order Number 111979.

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Sutton, James E.

Survey of sport
shellfishing potential
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TABLE OF CONTENTS

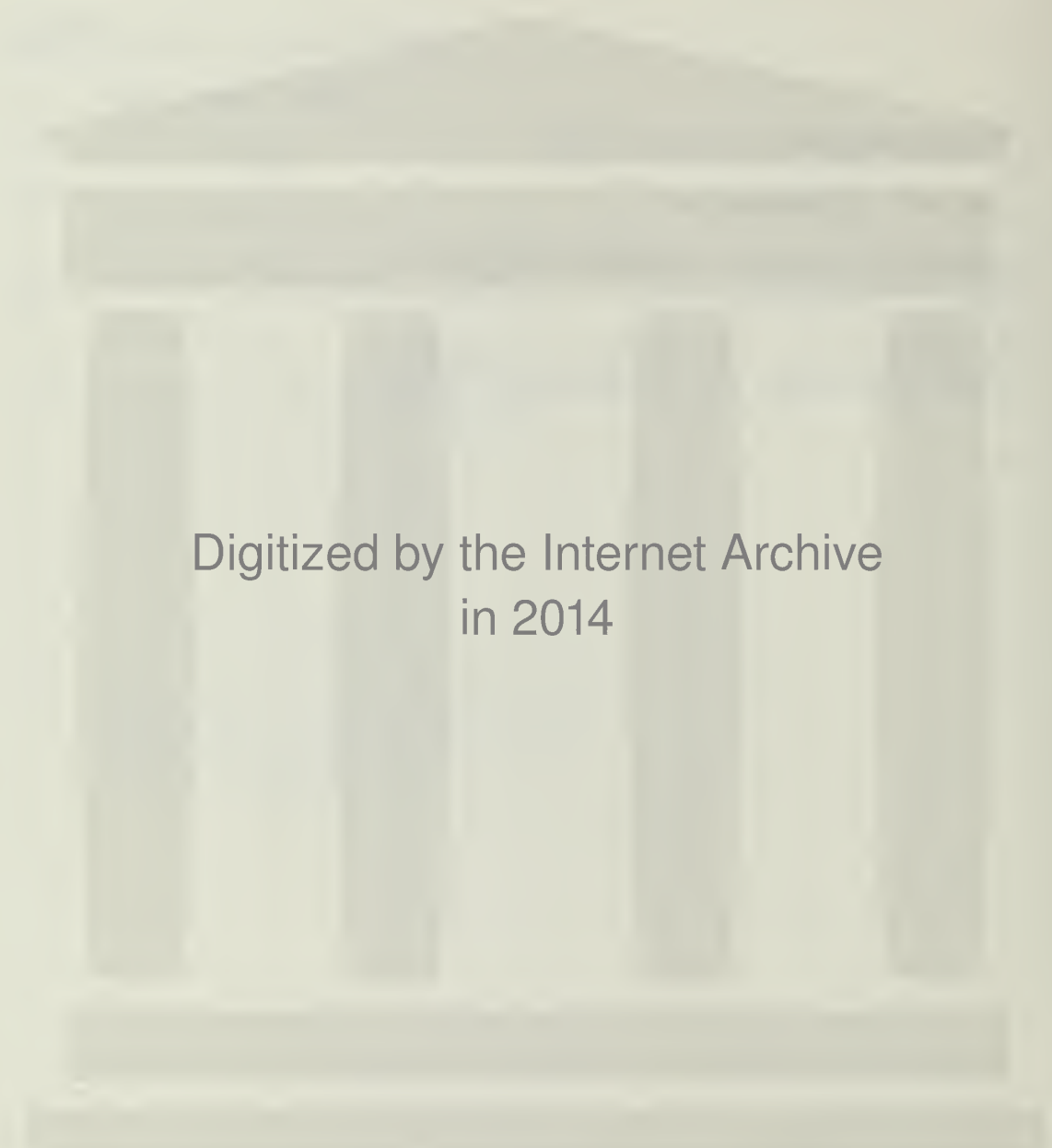
		Page
	LIST OF FIGURES	ii
	LIST OF TABLES	iii
I.	INTRODUCTION	1
	Objectives	1
	Previous Studies	2
II.	MATERIALS AND METHODS	4
III.	STUDY AREA	7
IV.	SPECIES REVIEW	11
V.	SPECIES DISTRIBUTIONS AND DENSITIES	14
	A. Warm Water Cove	16
	B. Islais Creek	27
	C. India Basin	30
	D. Yosemite Channel	33
	E. South Basin	38
	F. Candlestick Point - North	41
	G. Candlestick Point - South	45
	H. Candlestick Causeway	50
	I. Sierra Point	55
	J. Brisbane Lagoon	59
VI.	SIZE AND UTILIZATION OF SHELLFISH RESOURCES	64
VII.	EFFECTS OF WET WEATHER OVERFLOWS ON SHELLFISH POPULATIONS	69
VIII.	COMPARISON TO PREVIOUS STUDIES	70
IX.	SUMMARY	73
X.	ACKNOWLEDGMENTS	75
XI.	LITERATURE CITED	76
	APPENDICES	
	A. Preliminary Shellfish Survey Report	A-1
	B. Sample Data	B-1

LIST OF FIGURES

		Page
1.	General Survey Areas	15
2.	Warm Water Cove	25
3.	Islais Creek	28
4.	India Basin	31
5.	Yosemite Channel	34
6.	South Basin	39
7.	Candlestick Point - North	42
8.	Candlestick Point - South	46
9.	Candlestick Causeway	51
10.	Sierra Point	56
11.	Brisbane Lagoon	60
12.	Reported and actual locations of Wooster (1967) shellfish beds, and location of EPA (1972) samples	72

LIST OF TABLES

		Page
1.	Comprehensive Species List	8
2.	Outfall Information	17
3.	Summary of Survey Results (*Tapes*, *Mya* and *Zirfaea* only)	18
4.	Comparison of Populations of *Tapes* from Exploited and Unexploited Areas	66



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I. INTRODUCTION

Revised regulations for wet weather combined sewer overflows from the San Francisco system into San Francisco Bay are being developed at the present time. The final regulations may in part be determined by the presence of shellfish beds in the outfall areas, the extent to which these beds may be utilized in sport shellfishing, and the possible effects of such overflows on these beds. A study was initiated by the Bureau of Sanitary Engineering in June 1978 to determine the distribution and size of potential shellfish beds along the shoreline of southeastern San Francisco and northern San Mateo Counties.

OBJECTIVES

The general objectives of the study were as follows:

1. Determine location and size of shellfish beds in areas which might be influenced by wet weather bypasses;

2. Determine the general species composition and size structure of the shellfish beds at one point in time;

3. Determine present and potential public access to the beds, and the extent of present exploitation of the shellfish.

The study was not designed to consider questions concerning the health of the shellfish; or the long term population dynamics, growth rates, recruitment or other aspects of the ecology of the shellfish species.

To achieve the goals of the study, a two-part survey was initiated in June 1978. The first part consisted of a reconnaissance survey to determine, in a general way, appropriate sampling areas, access points, tidal effects, and other problems. No quantitative samples were taken, but field notes and extensive observations were compiled, and a few specimens were taken for taxonomic confirmation. The results of that survey were presented in a preliminary report (Sutton, 1978, attached as Appendix A), and plans for a more definitive survey developed from it.

PREVIOUS STUDIES

The only major previous study of any of the areas under consideration here was made by Wooster (1968 a, b). He walked most of the shoreline of San Francisco and San Pablo Bays, including part of the area included in the present study. He took limited samples, estimated the size of the beds in each area, and extrapolated his sample data to make an estimate of the number of clams in each bed. That "one-time" survey did not consider seasonal or annual effects. Wooster examined six areas in the shoreline included in the present study; these beds ranged in area from 500 to 19,000 square feet, and contained the soft shell clam, Mya arenaria, and the Japanese littleneck clam, Tapes japonica. Only two areas, the Bayview Park bed and the Visitacion Valley (Candlestick Causeway) beds contained large numbers of clams. His estimates were based on quantitative samples in each bed totaling no more than three square feet in any one bed (three samples).

Wooster's work was repeated to some extent by an Environmental Protection Agency study conducted in 1972 (U.S. Environmental Protection Agency, 1974). Nineteen of the 42 beds studied by Wooster were re-sampled, and a 50 percent reduction in clam biomass and density was reported. A report for the Association of Bay Area Governments (ABAG) reviewing shellfisheries in San Francisco Bay (Jones and Stokes Associates, Inc., 1977) reviewed and discussed Wooster's findings. The report suggested that Wooster may have seriously underestimated the density of shellfish in the areas he surveyed. The report noted work by Walt Dahlstrom (California Department of Fish and Game) who resurveyed a bed in Foster City previously studied by Wooster. Dahlstrom reported a density approximately four times greater than that determined by Wooster, based on a much larger number of samples. Because none of the studies sought to consider seasonal or annual variations in population density, or the effects of subsequent filling, harvesting, etc., the differences cannot unequivocally be attributed to sampling effects alone.

Because we possess only very limited knowledge of the population dynamics of shellfish species in San Francisco Bay, the results presented herein should be considered a general measure of the status of shellfish populations in summer, 1978. Direct comparisons to the results of other surveys, past or future, should be made with great caution, particularly with regard to possible increases or decreases in population density per unit area. Extrapolations of the data to considerations of the possible effects of pollution, droughts, filling, dredging or

other phenomena are not warranted on the basis of the data available at present.

II. MATERIALS AND METHODS

On 16 June 1978 the results of the preliminary survey (Sutton, 1978) were presented at a meeting attended by representatives of the Bureau of Sanitary Engineering of the City and County of San Francisco, the California Department of Fish and Game, State Water Resources Control Board, San Francisco Regional Water Quality Control Board, and the California Academy of Sciences. On the basis of these results, a general plan for quantitative sampling was developed. The plan called for a series of transects across the intertidal beach fronts and mud flats, with samples taken at regular intervals. Subsequent meetings with BSE staff developed a proposed regime as follows: beach front areas: transect every 100 meters, with a sample taken approximately every four meters across the beach front; mud flats: transects every 300 meters, with samples taken approximately every 20 meters. The sample size in all cases was to be a rectangle of 0.1 m^2 surface area. At the 16 June meeting, the consultant was given the freedom to "adjust the suggested procedure to fit field conditions and available resources".

The proposed sampling regime was followed closely in the initial stages of the program, but soon had to be abandoned in favor of other methods because of the limited number of low tide hours available during the study period. Changes were also dictated for other reasons, including the lack of water to

wash samples in some areas (due to exposure of broad mud flat areas), and the extensive time required to process clay and mud samples. In addition, it was determined that there was relatively little variability in the composition of the mud flat fauna, so that an extensive series of samples from these areas would not be warranted.

The alternative plan employed methods similar to those of Wooster, which are appropriate to sample large areas of beach front. Single or multiple samples were taken at numerous locations in each area surveyed, in those locations which appeared to have potential as shellfish habitats (based on appropriate substratum, presence of live specimens or empty shells, indication of clamming activity, etc.). In addition to the quantitative samples, the shoreline was frequently spotchecked (nonquantitatively) to determine the size and composition of the entire bed. Certain substrata did not have to be investigated thoroughly because previous observations indicated that no shellfish would be found there.

Quantitative samples were taking by digging with a shovel an area of approximately 0.1 m^2; these samples were dug to various depths depending upon the type of substratum present. In all cases it was determined that the sample was dug to a depth sufficient to obtain all of the clams present in the substratum. In cases of heavy gravel or rocky substrata it was sometimes impossible to dig the samples with a shovel; instead the sample was dug by hand or with the aid of a small garden cultivator.

Because the excavation tended to fill with dirty water and mud, the clams had to be located by touch only; it is therefore probable that a few clams, in particular the smallest specimens, may have escaped detection, somewhat biasing the results. However, thorough examination of the excavation kept this error to a minimum, and the estimate of the number of large-size clams in the sample should not be affected.

Samples were washed on a large geology sampling screen, with openings of approximately ¼ inch (6.35 mm). The screen was then picked thoroughly to remove all bivalves, gastropods, polychaetes, and other macrofauna. The only regular exception was the ubiquitous and very abundant small green shore crab Hemigrapsus oregonensis (Dana, 1851) (Family Grapsidae). Observations were taken of location, general sediment type, and other pertinent data; each sample was placed in a plastic bag and labelled. No detailed sediment particle analyses were made.

Specimens were fixed in 10 percent formalin solution for at lease one week, and then transferred to 75 percent ethanol as a preservative. The specimens and all field notes, data summaries and other pertinent materials will be maintained indefinitively as part of the San Francisco Bay collections in the Department of Invertebrate Zoology at the California Academy of Sciences.

Bivalves were measured along the greatest shell length, and the data were grouped in one centimeter size classes (0.1-1.0; 1.1-2.0, etc.). A summary of the identifications

and densities for all species, and the size class distributions for all bivalve species from each sample is presented in Appendix B. For purposes of discussion, clams will be referred to as "large" (3.8 cm or longer shell length, the minimum legal length for Tapes) or "small" (less than 3.8 cm shell length), since minimum legal shell length has not been defined for all species.

Specimens were identified with the aid of standard identification manuals, including Smith and Carlton (1975), Keen and Coan (1974), Fitch (1953) and Hartman (1968; 1969); taxonomy follows Smith and Carlton (1975). A summary list of species is presented in Table 1.

III. STUDY AREA

Most of the areas included in the survey are composed of man-made fill areas overlying natural mudflats; thus, the general form of the shoreline is rather consistent throughout. The fill area itself is usually bordered by large broken concrete blocks, asphalt, bricks, or gunnite. The base of this riprap is usually above, or just at the edge of the intertidal area, though in some areas it constitutes a substantial portion of the intertidal area as well. Below this riprap is a beach front area, typically composed of gravel, broken shells, broken rock or

TABLE 1.
COMPREHENSIVE SPECIES LIST

MOLLUSCA

BIVALVIA

ORDER: MYTILOIDA
FAMILY: MYTILIDAE
Ischadium demissum (Dillwyn, 1817) (ribbed horsemussel)
Musculus senhousia (Benson, 1842) (mud mussel)
Mytilus edulis Linnaeus, 1758 (bay mussel)

ORDER: PTERIOIDA
FAMILY: OSTREIDAE
Ostrea lurida Carpenter, 1864 (native or Olympia oyster)

ORDER: VENEROIDA
FAMILY: TELLINIDAE
Macoma balthica (Linnaeus, 1758)
Macoma inquinata (Deshayes, 1855)
Macoma nasuta (Conrad, 1837) (bent-nosed clam)
FAMILY: VENERIDAE
Tapes japonica Deshayes, 1853 (Japanese littleneck cla)

ORDER: MYOIDA
FAMILY: MYIDAE
Cryptomya californica (Conrad, 1837)
Mya arenaria Linnaeus, 1758 (soft-shell clam; steamer clam)
FAMILY: PHOLADIDAE
Zirfaea pilsbryi Lowe, 1931 (rough piddock)

GASTROPODA

ORDER: NEOGASTROPODA
FAMILY: MELONGENIDAE
Busycotypus canaliculatus (Linnaeus, 1758)* (channeled whelk)
FAMILY: MURICIDAE
Urosalpinx cinerea (Say, 1822)* (oyster drill)
FAMILY: NASSARIIDAE
Ilyanassa obsoletus (Say, 1822) (mud snail)

ANNELIDA

POLYCHAETA

ORDER: PHYLLODOCIMORPHIDA
FAMILY: GLYCERIDAE
Glycera robusta Ehlers, 1868
FAMILY: NEPHTYIDAE
Nephtys caecoides Hartman, 1938
FAMILY: NEREIDAE
Neanthes succinea (Frey and Leuckart, 1847)
Neanthes virens (Sars, 1835)
Neanthes sp.
Nereis vexillosa Grube, 1851 (epitokous)

TABLE 1. (cont'd)

ANNELIDA

POLYCHAETA

ORDER: CIRRATULIMORPHIDA
FAMILY: CIRRATULIDAE
Cirriformia spirabrancha (Moore, 1904)

ORDER: CAPITELLIMORPHIDA
FAMILY: MALDANIDAE
possible *Asychis elongata* (Verrill, 1873)
(pygidium missing)

ARTHROPODA

EUCARIDA

ORDER: DECAPODA

SECTION: CARIDEA
FAMILY: PALAEMONIDAE
Palaemon macrodactylus Rathbun, 1902

SECTION: ANOMURA
FAMILY: CALLIANASSIDAE
Upogebia pugettensis (Dana, 1852) (blue mud shrimp)

FAMILY: PAGURIDAE
unidentified hermit crabs

SECTION: BRACHYURA
FAMILY: GRAPSIDAE
Hemigrapsus oregonensis (Dana, 1851)*

CHORDATA

ASCIDIACEA

ORDER: ENTEROGONA
FAMILY: ASCIDIIDAE
Ascidia ceratodes (Huntsman, 1912)

ORDER: PLEUROGONA(?)
FAMILY: MOLGULIDAE(?)
possible *Molgula manhattensis* (DeKay, 1843)

OSTEICHTHYES

ORDER: PERCIFORMES
FAMILY: BATRACHOIDIDAE
Porichthys notatus Girard 1854 (plainfin midshipman)*

*specimens not retained in collections

cobbles, with mud or sand between and below these larger elements. This beach front typically slopes down to the mud flat proper at a slope of 6 - 10°. The beach front may be heavily overgrown seasonally with patchy areas of the green algae Ulva (sea lettuce) and/or Enteromorpha; a few areas, such as the tip of Candlestick Point and the culvert area of Candlestick Causeway, may also have a variety of attached red algae. In addition, a thick coat of brown diatoms may often form over rocks and the adjacent mud flat area.

The mud flats proper have a much more gentle slope than the beach front, usually around 1-2°. The mud may have extensive shell debris in some areas, and may be pocked by depressions formed by fish burrowing for food.

Underlying both the beach front and the mud flat in most areas is a thick layer of very dense gray clay, which is relatively impermeable to water, and which generally has few if any living shellfish in it, except for a few deeply burrowing species. In some locations the clay forms solid banks on the beach front or just beneath the surface; few shellfish or other organisms are found here.

Because of the many sources of the fill material, the intertidal substrata tend to be rather heterogeneous and patchy in distribution. Consequently, the fauna also tend to exhibit a patchy distribution, occurring primarily in those areas with suitable substrata. It is, therefore, imprudent to extropolate

too far from one sample site on the assumption that a large section of shoreline is similar. On the other hand, spotchecking has demonstrated that the general outlines of a shellfish bed can be estimated by examination of the substratum.

Certain areas, such as the new pier in India Basin, are being filled at the present time. Such areas subject any fauna present to smothering, heavy siltation, and erosion; thus established fauna beds are usually absent.

IV. SPECIES REVIEW

The species studied in the present program have been discussed extensively in other publications (Fitch, 1953; Hanna, 1966; Wooster, 1968 a; Smith and Carlton, 1975; Jones & Stokes Associates, Inc., 1977) so only brief pertinent comments will be included here.

The two species most commonly collected by shellfishers are the Japanese littleneck clam, Tapes japonica Deshayes, 1853, introduced from the Orient, and the softshell clam (also called the long neck or steamer clam), Mya arenaria Linnaeus, 1758, introduced from the East Coast. Tapes has apparently largely replaced the native littleneck clam Protothaca staminea (Conrad, 1837) in most bay habitats; no specimens of Protothaca were found in the study. Tapes primarily inhabits the stony beach front areas, often in densities greater than $100/m^2$. It is a "nestler", and unlike most species of the Family Veneridae, is able to attach to small stones and shell fragments by means of a byssus, most commonly seen in mussels (Family Mytilidae).

However, unlike the mytilids, no specimens of Tapes were found with byssal threads attached directly to the shells of other live specimens. Fitch (1953) reports Tapes may obtain a shell length of three inches (7.6 cm).

Mya arenaria, a large clam (shell length to five inches (12.7 cm; Fitch, 1953)) with long siphons, is capable of burrowing to some depth into soft sediments. It was expected that it would be found primarily in the mud flats. In fact, this species was found to have two distinct distribution patterns: small specimens, those under about two or three centimeters in length, were found in most of the mud flats examined. They were buried a few centimeters under the surface, often in densities exceeding $1000/m^2$. Large specimens were virtually always found up in the beach front areas, mixed with, or buried deeper than, Tapes. A few small specimens (generally less than $30/m^2$) were also found in the higher intertidal areas, but large Mya were rare in most mud flats (less than $1/m^2$). While further work is required, these results suggest that those small specimens in the beach front are able to grow to large size, while the vast majority of specimens in the mud flats do not, perhaps because of heavy predation by fish and shore birds. Wooster (1968 a) reported excavations of mud flat areas by fish; some areas examined in the present study, in particular the mud flats along the Candlestick Causeway, exhibited similar excavations.

Prior to the initial survey, it was anticipated that large numbers of the ribbed horsemussel, Ischadium demissum (Dillwyn, 1817), would be found in some areas. However, only a single

specimen was found, in a rocky bank in Yosemite Channel during the preliminary survey. Large specimens of the bay mussel Mytilus edulis Linnaeus, 1758 were also rather rare, except for a few concentrations. Another mytilid, the mud mussel, Musculus senhousia (Benson, 1842), and several tellinids of the genus Macoma occurred in some areas, but these are too small or too uncommon to consider as potential shellfishery items.

An unexpected discovery was the finding of several beds of the rough piddock clam, Zirfaea pilsbryi Lowe, 1931 (Family Pholadidae). These beds were found in mud and clay substrata. This clam, which may have a shell length of five inches (12.7 cm; Fitch, 1953), is used for both bait and food. It has the highest meat to shell weight ratio of any of the species with shellfishery potential.

The native oyster, Ostrea lurida Carpenter, 1864, was found scattered over much of the survey area, usually attached to the undersides of large cobbles in the beach front. Although Fitch (1953) reported that specimens may attain a length of 2½ inches (6.4 cm), most of the specimens observed were under 1½ inches (3.8 cm) in length. Because the species was always uncommon and small, and because specimens are difficult to detach intact, the oysters were not sampled quantitatively, and no attempt was made to determine population densities. In no area were enough specimens present to support sport harvesting.

Only one gastropod was found which has any sportfishery potential. This is the channeled whelk, Busycotypus canaliculatus

(Linnaeus, 1758) (Family Melongenidae), found to be locally common in several locations. This species, introduced from the Atlantic, may grow to a shell length of six inches (15.2 cm; Dustin Chivers, pers. comm.).

Several other species are sufficiently large, common, or accessible to constitute locally important species, but for use as bait rather than as food. These species include the ghost shrimp, Callianassa californiensis Dana, 1854, and the blue mud shrimp, Upogebia pugettensis (Dana, 1852) (both Family Callianassidae); and several large polychaetes. All of these species are taken by digging or by the use of "slurp guns" to suck the organisms out of their tubes.

Only three species (Tapes, Mya and Zirfaea) are sufficiently large, numerous, broadly distributed and accessible to be considered as potential sportfishery items, and discussion of the survey areas will therefore concentrate on these species. Other species of interest in one or more areas will be considered briefly as appropriate.

V. SPECIES DISTRIBUTIONS AND DENSITIES

Ten areas, designated A to J, were sampled quantitatively during the main survey. The geographic area extended from Warm Water Cove in the Potrero area of San Francisco south to and including Sierra Point in San Mateo County, plus Brisbane Lagoon (fig. 1). The area around Oyster Point, which was examined in the preliminary survey, was not sampled further because of limited

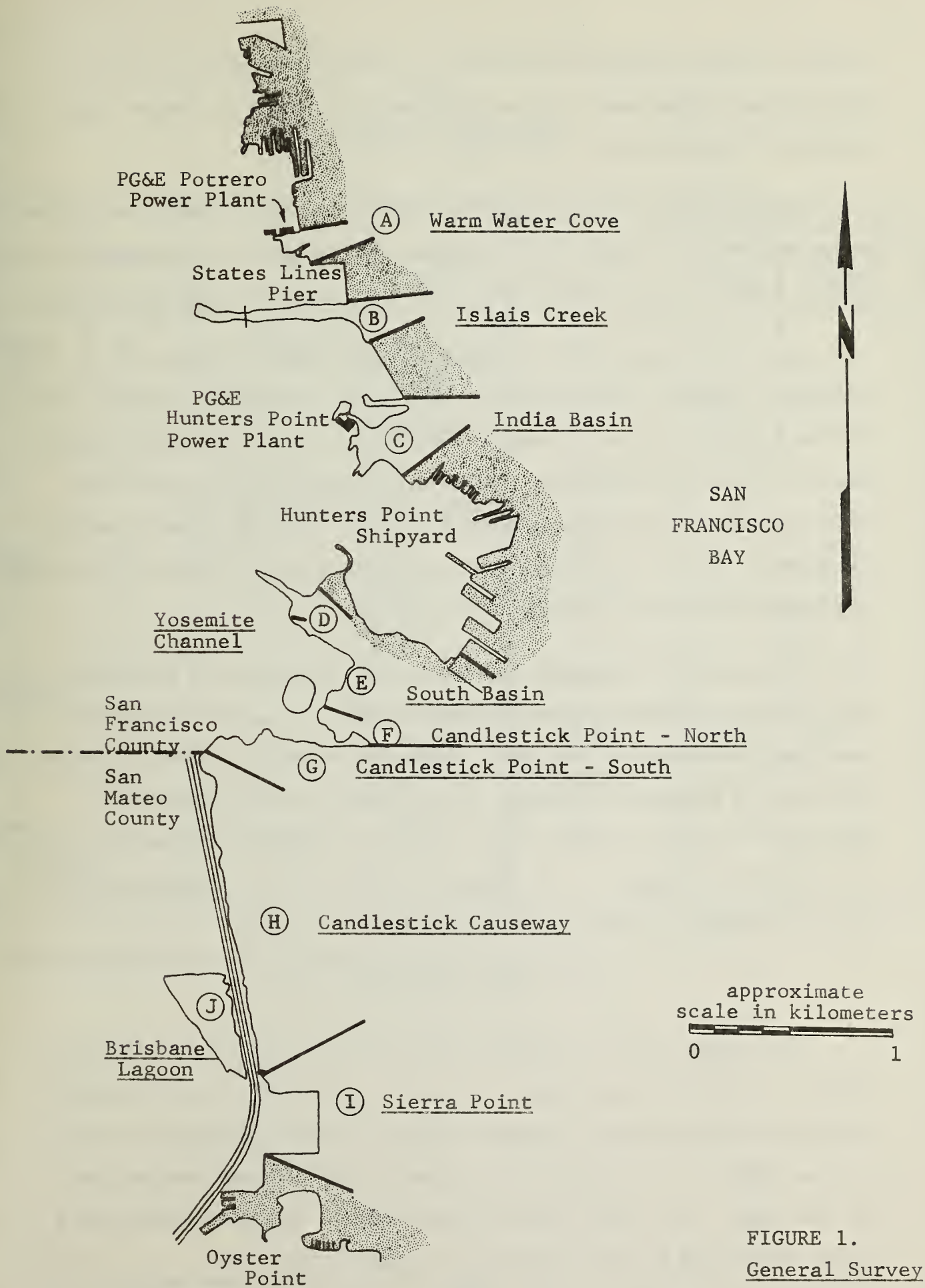

FIGURE 1.
General Survey
Areas

field time and because the results of tests conducted at the U.S. Army Corps of Engineers Bay-Delta Hydraulic Model indicated that little if any overflow would contact this area.

As noted above, quantitative samples and spot checks were made in each area, and the size of various shellfish beds estimated.* Public access to each area was noted, and present usage estimated.

Each sample has been assigned a code number. Single (non-transect) samples are coded for study area and sample number. Thus, J-3 designates the third sample from study area J (Brisbane Lagoon). Samples taken along transect lines are coded for the study area, transect number, and sample number. Thus, C-3-2 designates sample 2, from transect 3, in study area C (India Basin). Both quantitative and non-quantitative samples are so coded.

The maps also indicate prominent features such as buildings and outfalls, general types of beach composition, and shoreline sections discussed in the text. Each San Francisco combined sewer overflow is numbered according to the San Francisco Wastewater Management Program system, and relevant information concerning it is presented in Table 2. A summary of bed size and population data for all areas is presented in Table 3.

A. WARM WATER COVE

This small area is located just south of the Pacific Gas and Electric Potrero Power Plant; the name is derived from the warmed cooling water entering the cove from the outfall for units 1 and 2 of the plant. The outfall is located at the extreme western end of the cove. The south shore of the cove is being developed as a small park, and a fishing pier is in place (fig. 2).

*Widths were measured in the field; length were estimated in the field or scaled from maps or aerial photographs.

TABLE 2.

OUTFALL INFORMATION

LOCATION	OUTFALL # *	NAME	Size (diameter)	Cross-Section Area (ft^2)	TRIBUTARY AREAS (Acres)	
					SEWERED	UNSEWERED
Islais Creek	42	N. Side 3rd St.	3'6" x 5'3"	14.0	279	153
"	43	Marin	8'10"	74.7	1,410	1,410
"	44	Selby	3@7'x10'	209.1	3,307	3,307
"	45	Rankin	5'	19.6	66	66
"	46	S. Side 3rd St.	2'6"x3'9"	7.3	63	57
India Basin	48	Evans	6'	28.3		260
"	49	Hudson	30"	4.9	667	45
"	50	Griffith N.	21"	2.4		17
Yosemite Channel	51	Griffith S.	5'6"	23.8	551	182
"	52	Yosemite	9'x7'3" 11'6"x6'6"	52.9 69.6	1,047	1,047
"	53	Fitch	6'9"	35.8	350	121
Candle-stick Causeway	54	Sunnydale	6'6"	33.2	832	594

*San Francisco Wastewater Management Program system numbers.

TABLE 3

SUMMARY OF SURVEY RESULTS

(TAPES, MYA & ZIRFAEA ONLY)

These densities are estimates of beach front only. Because of the difficulty in establishing boundaries for mud flat areas, no attempt was made to estimate densities from these areas.

AREA[a]	SECTION[a]	SPECIES	AREA SAMPLED (M^2)	# OF SAMPLES	SAMPLE NOTATION	ESTIMATED BED DIMENSIONS (M)	ESTIMATED BED AREA (M^2)	ALL SIZES		LARGE CLAMS ONLY[b]		
								ESTIMATED #/M^2	ESTIMATED TOTAL #	ESTIMATED #/M^2	ESTIMATED TOTAL #	% OF SAMPLES[c]
A	1	TAPES	0.1	1	A-1-2	2 x 80	160	60	9,600	30	4,800	50.0
WARM	2	TAPES	0.1	1	A-2	3 x 120	360	350	126,000	200	72,000	57.1
WATER	3	TAPES	0.1	1	A-3	15 x 60	900	360	324,000	30	27,000	8.3
COVE	3	MYA	0.1	1	A-3	15 x 60	900	10	9,000	0	0	0.0
	SUBTOTAL	TAPES	0.3	3	-	-	1420	-	459,600	-	103,800	-
		MYA	0.1	1	-	-	900	-	9,000	-	0	-
B	1	TAPES	0.1	1	B-1	2 x 75	150	60	9,000	0	0	0.0
ISLAIS CREEK	2	TAPES	0.1	1	B-2	2 x 30	60	110	6,600	20	1,200	18.2
	SUBTOTAL	TAPES	0.2	2	-	-	210	-	15,600	-	1,200	-
C	1	TAPES	0.3	3	C-1-1,C-1-2 C-1-3,	5 x 125	625	230	143,750	0	0	0.0
INDIA	2	TAPES	0.1	1	C-2-2	2 x 160	320	540	172,800	50	16,000	9.3
BASIN	2	MYA	0.1	1	C-2-2	2 x 160	320	10	3,200	10	3,200	100.0
	4	TAPES	0.2	2	C-3-1,C-3-2	2 x 100	200	510	102,000	15	3,000	2.2
	SUBTOTAL	TAPES	0.6	6	-	-	1145	-	418,440	-	19,000	-
		MYA	0.1	1	-	-	320	-	3,200	-	3,200	-

TABLE 3

(Continued)

AREA[a]	SECTION[a]	SPECIES	AREA SAMPLED (M^2)	# OF SAMPLES	SAMPLE NOTATION	ESTIMATED BED DIMENSIONS (M)	ESTIMATED BED AREA (M^2)	ALL SIZES		LARGE CLAMS ONLY[b]		
								ESTIMATED #/M^2	ESTIMATED TOTAL #	ESTIMATED #/M^2	ESTIMATED TOTAL #	% OF SAMPLES[c]
D	3	TAPES	0.1	1	D-3	1.5 x 80	120	220	26,400	160	19,200	72.7
YOSEMITE	3	MYA	0.1	1	D-3	1.5 x 80	120	40	4,800	40	4,800	100.0
CHANNEL	4	TAPES	0.1	1	D-4	1.5 x 100	150	70	10,500	20	3,000	28.6
	5	TAPES	0.1	1	D-1-2	4 x 50	200	60	12,000	10	2,000	16.7
	5	MYA	0.1	1	D-1-2	4 x 50	200	300	60,000	20	4,000	6.7
	7	TAPES	0.1	1	D-2-1	3 x 130	390	240	93,600	110	42,900	45.8
	7	MYA	0.1	1	D-2-1	3 x 130	390	20	7,800	10	3,900	50.0
	8	TAPES	-	-	-	3 x 170	510	-	-	200[d]	102,000[d]	-
	SUBTOTAL	TAPES	0.4	4	-	-	860[e]	-	142,500[e]	-	67,000[e]	-
		MYA	0.3	3	-	-	710	-	72,600	-	12,700	-

TABLE 3

(Continued)

AREA[a]	SECTION[a]	SPECIES	AREA SAMPLED (M^2)	# OF SAMPLES	SAMPLE NOTATION	ESTIMATED BED DIMENSIONS (M)	ESTIMATED BED AREA (M^2)	ALL SIZES		LARGE CLAMS ONLY[b]		
								ESTIMATED #/M^2	ESTIMATED TOTAL #	ESTIMATED #/M^2	ESTIMATED TOTAL #	% OF SAMPLES[c]
E	3	TAPES	0.1	1	E-2	2 x 75	150	60	9,000	30	4,500	50.0
SOUTH	3	MYA	0.1	1	E-2	2 x 75	150	20	3,000	20	3,000	100.0
BASIN	4	TAPES	0.1	1	E-3	4 x 120	480	390	187,200	120	57,600	30.8
	4	MYA	0.1	1	E-3	4 x 120	480	10	4,800	10	4,800	100.0
	6	TAPES	0.4	4	E-4,E-5, E-6,E-7	10 x 150	1500	2	3,000	0	0	0.0
	6	MYA	0.4	4	E-4,E-5, E-6,E-7	10 x 150	1500	22	33,000	0	0	0.0
	6	ZIRFAEA	0.4	4	E-4,E-5, E-6,E-7	10 x 150	1500	7	10,500	7	10,500	100.0
	7	TAPES	0.1	1	E-8	3 x 150	450	140	63,000	0	0	0.0
	SUBTOTAL	TAPES	0.7	7	-	-	2580	-	262,200	-	62,100	-
		MYA	0.6	6	-	-	2130	-	40,800	-	7,800	-
		ZIRFAEA	0.4	4	-	-	1500	-	10,500	-	10,500	-

TABLE 3

(Continued)

AREA[a]	SECTION[a]	SPECIES	AREA SAMPLED (M^2)	# OF SAMPLES	SAMPLE NOTATION	ESTIMATED BED DIMENSIONS (M)	ESTIMATED BED AREA (M^2)	ALL SIZES		LARGE CLAMS ONLY[b]		
								ESTIMATED #/M^2	ESTIMATED TOTAL #	ESTIMATED #/M^2	ESTIMATED TOTAL #	% OF SAMPLES[c]
F	3	TAPES	0.1	1	F-2	3 x 90	270	80	21,600	0	0	0.0
CANDLESTICK	3	MYA	0.1	1	F-2	3 x 90	270	120	32,400	0	0	0.0
POINT-NORTH	4	TAPES	0.1	1	F-3	10 x 180	1800	210	378,000	0	0	0.0
	4	MYA	0.1	1	F-3	10 x 180	1800	3340	6,012,000	0	0	0.0
	5	TAPES	0.3	3	F-4,F-5, F-6	10 x 100	1000	10	10,000	0	0	0.0
	5	MYA	0.3	3	F-4,F-5, F-6	10 x 100	1000	117	117,000	0	0	0.0
	5	ZIRFAEA	0.3	3	F-4,F-5, F-6	10 x 100	1000	10	10,000	7	7,000	70.0
	6	TAPES	0.1	1	F-7	3 x 50	150	10	1,500	10	1,500	100.0
	6	MYA	0.1	1	F-7	3 x 50	150	40	6,000	0	0	0.0
	SUBTOTAL	TAPES	0.6	6	-	-	3220	-	411,100	-	1,500	-
		MYA	0.6	6	-	-	3220	-	6,167,400	-	0	-
		ZIRFAEA	0.3	3	-	-	1000	-	10,000	-	7,000	-

TABLE 3

(Continued)

AREA[a]	SECTION[a]	SPECIES	AREA SAMPLED (M^2)	# OF SAMPLES	SAMPLE NOTATION	ESTIMATED BED DIMENSIONS (M)	ESTIMATED BED AREA (M^2)	ALL SIZES		LARGE CLAMS ONLY[b]		
								ESTIMATED #/M^2	ESTIMATED TOTAL #	ESTIMATED #/M^2	ESTIMATED TOTAL #	% OF SAMPLES[c]
G CANDLESTICK POINT-SOUTH	1	TAPES	0.4	4	G-1-2,G-2 G-3-1, G-3-2	2 x 365	730	148	108,040	65	47,450	43.9
	1	MYA	0.1	1	G-1-2	2 x 120	240	30	7,200	20	4,800	66.7
	4	TAPES	0.2	2	G-5,G-6	2 x 275	550	270	148,500	90	49,500	33.3
	4	MYA	0.2	2	G-5,G-6	2 x 275	550	125	68,750	0	0	0.0
	6	TAPES	0.1	1	G-7	2 x 200	400	310	124,000	30	12,000	9.7
	6	MYA	0.1	1	G-7	2 x 200	400	40	16,000	10	4,000	24.0
	SUBTOTAL	TAPES	0.7	7	-	-	1680	-	380,540	-	108,950	-
		MYA	0.4	4	-	-	1190	-	91,950	-	8,800	-

TABLE 3

(Continued)

AREA[a]	SECTION[a]	SPECIES	AREA SAMPLED (M^2)	# OF SAMPLES	SAMPLE NOTATION	ESTIMATED BED DIMENSIONS (M)	ESTIMATED BED AREA (M^2)	ALL SIZES		LARGE CLAMS ONLY[b]		
								ESTIMATED #/M^2	ESTIMATED TOTAL #	ESTIMATED #/M^2	ESTIMATED TOTAL #	% OF SAMPLES[c]
H												
CANDLESTICK	2	TAPES	0.1	1	H-2	7 x 15	105	600	63,000	10	1,050	1.7
CAUSEWAY	2	MYA	0.1	1	H-2	7 x 15	105	130	13,650	0	0	0.0
	4	TAPES	0.325	3	H-3,H-4, H-5	1.5 x 1,100	1650	193	318,450	100	165,000	51.8
	4	MYA	0.1	1	H-3	1.5 x 120	180	20	3,600	20	3,600	100.0
	6	TAPES	0.4	4	H-6,H-8 H-9,H-10	2 x 880	1760	268	471,680	78	137,280	29.1
	6	MYA	0.4	4	H-6,H-8 H-9,H-10	2 x 880	1760	45	79,200	5	8,800	11.1
	SUBTOTAL	TAPES	0.925	9	-	-	5015	-	928,130	-	303,870	-
		MYA	0.6	6	-	-	2045	-	96,450	-	12,400	-
I	1	TAPES	0.2	2	I-1-1,I-2	2 x 500	1000	170	170,000	0	0	0.0
SIERRA	1	MYA	0.2	2	I-1-1,I-2	2 x 500	1000	460	460,000	0	0	0.0
POINT	2	TAPES	0.2	2	I-2,I-3	1.25 x 625	781	130	101,530	85	66,385	65.4
	2	MYA	0.2	2	I-1,I-3	1.25 x 625	781	10	7,810	0	0	0.0
	3	TAPES	0.125	1	I-4	1.25 x 275	344	152	52,288	88	30,272	57.9
	SUBTOTAL	TAPES	0.525	5	-	-	2125	-	323,818	-	96,657	-
		MYA	0.4	4	-	-	1781	-	467,810	0	0	-

TABLE 3

(Continued)

AREA[a]	SECTION[a]	SPECIES	AREA SAMPLED (M^2)	# OF SAMPLES	SAMPLE NOTATION	ESTIMATED BED DIMENSIONS (M)	ESTIMATED BED AREA (M^2)	ALL SIZES		LARGE CLAMS ONLY[b]		
								ESTIMATED #/M^2	ESTIMATED TOTAL #	ESTIMATED #/M^2	ESTIMATED TOTAL #	% OF SAMPLES[c]
J BRISBANE LAGOON	1	TAPES	0.65	4	J-1,J-2, J-3,J-4	2 x 97.5	195	214	41,730	68	13,260	31.8
	1	MYA	0.65	4	J-1,J-2, J-3,J-4	2 x 97.5	195	215	41,925	36	7,020	16.7
	3	TAPES	0.3	3	J-5,J-6, J-7	5 x 900	4500	160	720,000	37	166,500	23.1
	3	MYA	0.3	3	J-5,J-6, J-7	5 x 900	4500	17	76,500	17	76,500	100.0
	5	TAPES	0.2	2	J-9,J-10	1 x 550	550	200	110,000	65	35,750	32.5
	5	MYA	0.2	2	J-9,J-10	1 x 550	550	50	27,500	45	24,750	90.0
	SUBTOTAL	TAPES	1.15	9	-	-	5245	-	871,730	-	215,510	-
		MYA	1.15	9	-	-	5245	-	145,925	-	108,270	-
TOTAL ALL AREAS		TAPES	6.1	58	-	-	23,500	-	4,213,768[e]	-	979,687[e]	-
										-	1,081,687[f]	-
		MYA	4.25	40	-	-	17,541	-	7,095,135	-	153,170	-
		ZIRFAEA	0.7	7	-	-	2,500	-	20,500	-	17,500	-

(a) As described in text.
(b) 3.8 cm shell length or greater.
(c) Percent of large clams in each sample or group of samples, based on DENSITY/M^2.
(d) No sample taken; estimate only.
(e) Not including Yosemite Channel Section 8.
(f) Includes estimate of large Tapes in Yosemite Channel Section 8.

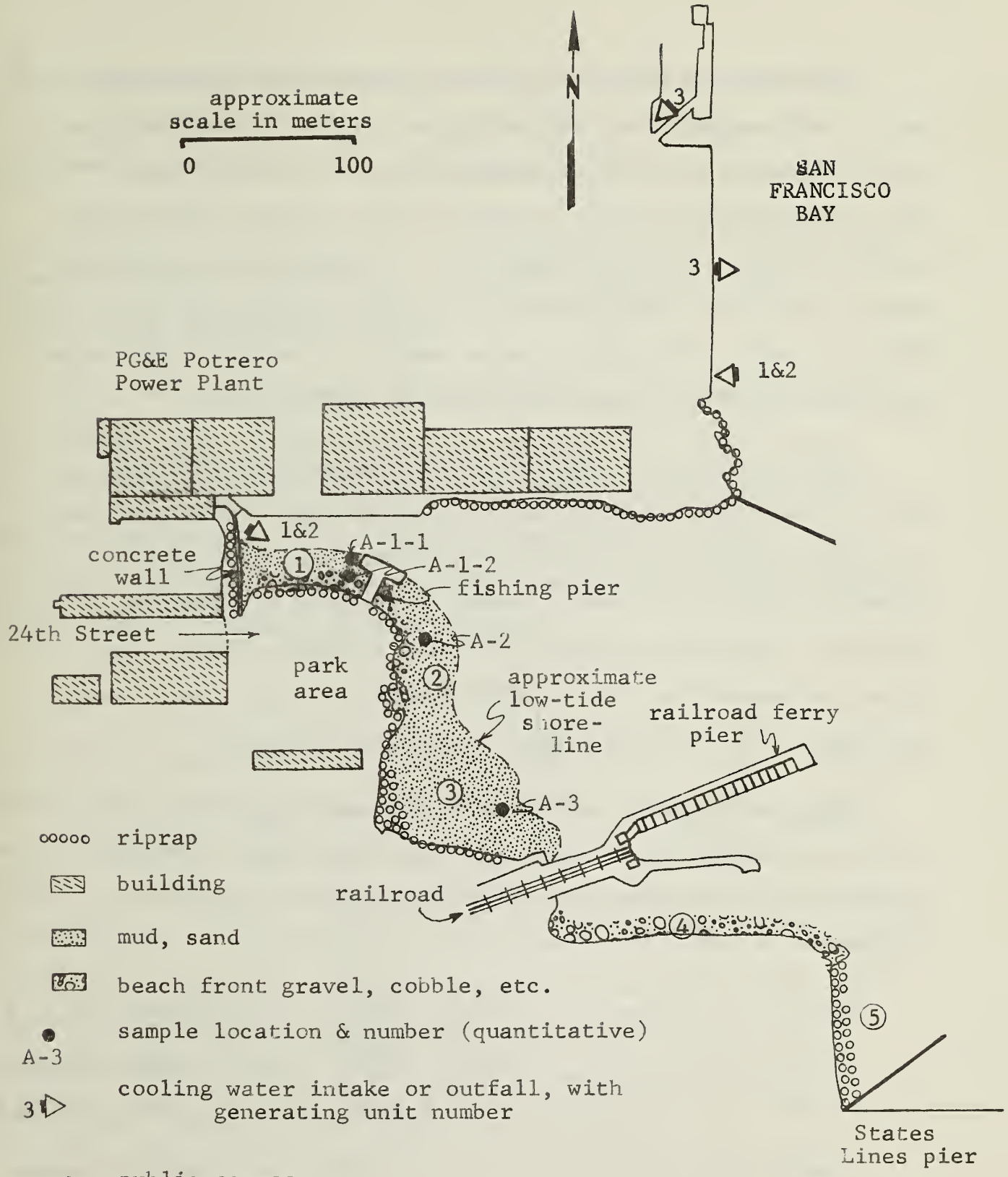

FIGURE 2.

(A) Warm Water Cove

The shoreline along the park is approximately 300 meters long. The cove is narrow at the western (outfall) end and opens up further east. The southern boundary is a railroad ferry pier. The intertidal zone, below the large riprap, consists of large concrete blocks, and some mud. In the southern portion the narrow intertidal band expands into a broad rectangular area, which is partly covered by a large number of old tires, and which consists of a shallow layer of rocks and mud over clay.

Three section were sampled in Warm Water Cove. Section 1, west of the pier, has shellfish in a narrow band 2-3 meters wide and about 80 meters long (A-1-2); no clams were found in the upper gravelly area (A-1-1). East and south of the pier in Section 2, the narrow band of shellfish continues (A-2). The large rectangular Section 3 supports some shellfish (A-3), but the numbers decline in the upper intertidal portions.

Tapes was found in all three areas; small Mya were common in the mud flats, but no large specimens were found. Area and population size estimates of large Tapes for the cove are as follows:

Section 1: 2 x 80 = 160 m^2 x 30/m^2 = 4,800 Tapes (sample A-1-2)
Section 2: 3 x 120 = 360 m^2 x 200/m^2 = 72,000 Tapes (sample A-2)
Section 3: 15 x 60 = 900 m^2 x 30/m^2 = 27,000 Tapes (sample A-3)

Immediately south of the railroad ferry pier is another narrow intertidal zone in a section of fill between the tracks and the States Lines pier. The eastern shore (Section 5) is large riprap

and probably supports few clams, but the gravelly north shore (Section 4), about 160 meters long, may have some Tapes. The area was not sampled, and no empty Tapes shells were observed.

Access is excellent to the shoreline park area; although the area south of the railroad pier is private property, there is ready access from the park area.

Warm Water Cove showed evidence of having been worked over by clammers; much of that effort may be for bait. Most digging was apparent in Section 3, where large areas of clay are exposed when the rocks are raked aside. The small numbers of large specimens (8.3% of specimens were large) in this area may reflect more intensive clamming. Sections 4 and 5 showed no evidence of clamming activity.

B. ISLAIS CREEK

Islais Creek (fig. 3) is a long (1560 meters) narrow, dredged, salt water channel south of Warm Water Cove. It is named after a small freshwater creek which once drained into the bay at that point. A total of five major sewers overflow into the channel at various points. Virtually the entire channel is bordered by old piers, piles and other structures, with no shellfish habitat and no access. A few large Mytilus and many barnacles were observed to be attached to the concrete bents of the freeway at the western terminus of the channel (Section 6).

One area which is accessible is a small beach (Section 1) on the north side of the channel east of the Third Street bridge;

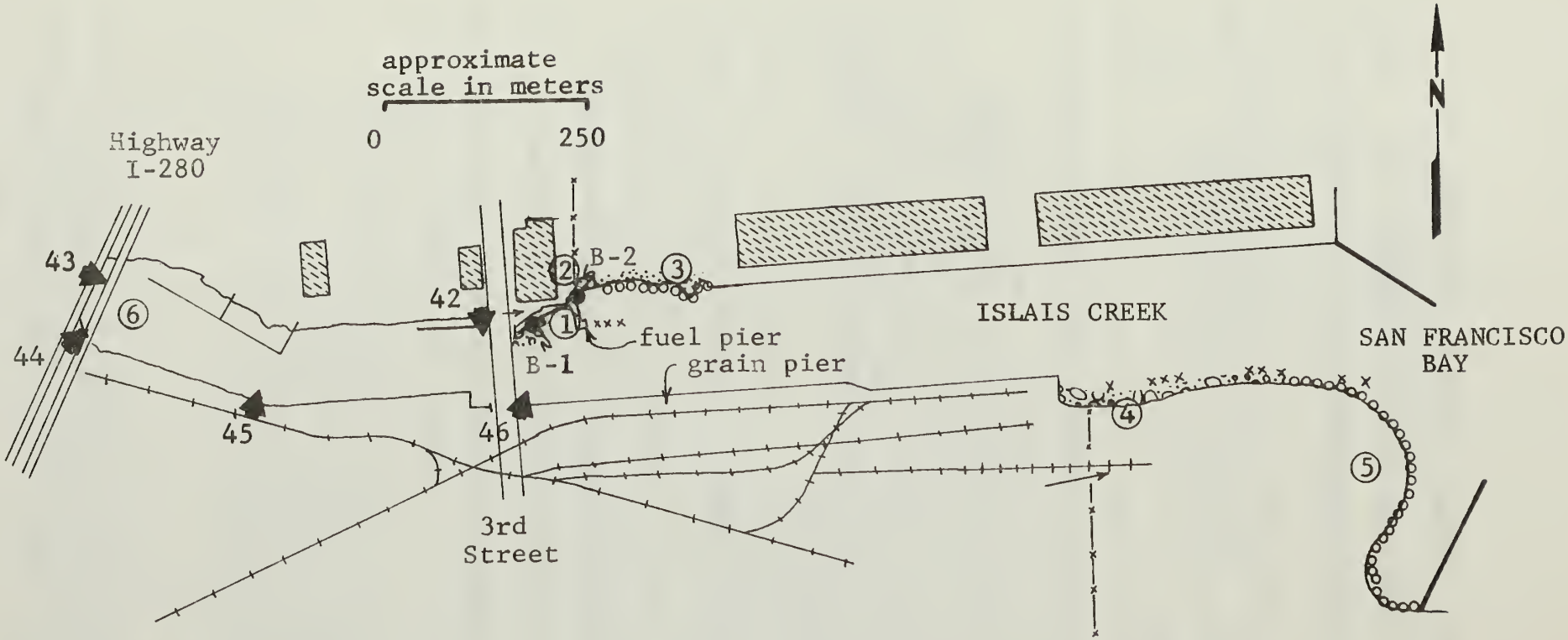

FIGURE 3.

(B) Islais Creek

it is about 95 meters in length. This small beach has a low breakwater, sand in the upper intertidal, and mud, gravel and cobbles further down, lying on clay. The beach continues east to a fuel pier (Section 2). Just east of the pier a fence separates the beach from a different beach front (Section 3) consisting of a small mud flat, a large sand and gravel upper intertidal zone, and large riprap with soft oily mud further down. Nothing was found here except a few small Mya.

Section 1 was found to have no large Tapes in the one sample taken (B-1); a few were found between the fuel pier and the fence in Section 2 (B-2). An estimate of the number of large Tapes in Section 2 is: $2 \times 30 = 60m^2 \times 20/m^2 = 1{,}200$ Tapes. A strong fuel odor was noted in the vicinity of the pier, so these clams may be tainted.

The beach (Section 1) showed signs of having been extensively disturbed, presumably by fishermen looking for bait.

The southern shore of the channel, at its eastern end, is marked private, and is fenced to vehicular traffic, but there are several footpaths beyond the fence. The area just east of the grain elevators (Section 4) may be suitable for Tapes; no samples were taken here, however. Further out, and along the east side of the fill (Section 5) the riprap consists of large concrete and asphalt blocks all the way around to the fence along the PFEL pier. There appears to be little probability of Tapes being present here in any numbers.

C. INDIA BASIN

India Basin (fig. 4) is the inlet bounded by the PFEL piers on the north and the Hunters Point Shipyard on the south. Three combined sewer overflows empty into the Basin, which is currently being bisected west to east by a new fill area extending from just north of the Pacific Gas and Electric Hunters Point Power Plant to a line even with the outer end of the PFEL pier.

Several areas were examined with multiple sample transects, and other locations were spotchecked. Section 1 is located just east of the outfalls for PG&E units 2 and 3. The intertidal area consists of mud and broken shells below large concrete riprap; the cooling water flows along the north side of a small channel at low tide. High densities of Tapes were found lying close to the surface under a detritus and diatom mat at the upper two samples (C-1-1 and C-1-2), but very few were found along the edge of the channel (C-1-3). All of the clams were small; no Mya were found.

Further around to the east, a second transect of three samples was established below the riprap adjacent to the outfall for Unit 4. This section (Section 2) consists of a thin cover of gravel and stones over dense clay; the mud flat was very soft. The upper sample (C-2-1) contained 15 small Tapes; just above the mud line (C-2-2) more Tapes, including some large specimens, and one large Mya were found. A few Tapes and one small Mya were found in the mud flat (C-2-3). Wooster (1968b) reported scattered pockets of Tapes in the vicinity of the power plant.

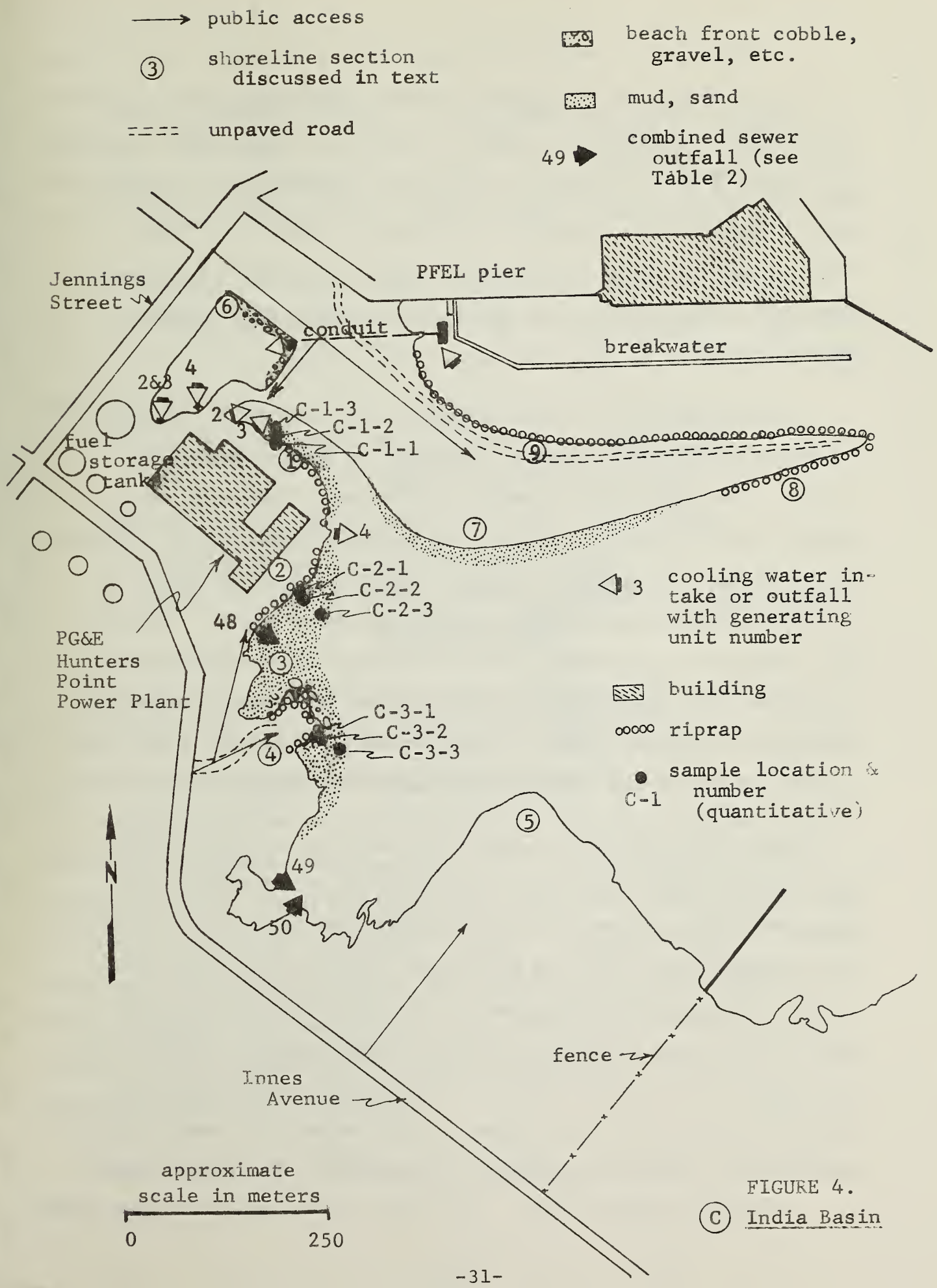

FIGURE 4.
(C) India Basin

South of a mud flat (Section 3), a third transect of three samples was established on the east side of a small boat launching ramp (Section 4), consisting of large concrete block riprap and a small beach front of rubble, surrounded by broad mud flats. Large numbers of Tapes were found in the beach front, but again almost all were small (C-3-1 and C-3-2); no Mya were found in the mud (C-3-3).

The predominance of small Tapes in the samples may reflect the heavy use of this area by fisherman, clammers, and bait hunters. The small launch ramp provides ready access to the banks around the power plant, a very popular fishing spot. Access to the intake area and the new fill (Sections 6, 7, 8 and 9) is available from Jennings Street behind the power plant. The mud flat (Section 3) is worked over very heavily by digging and by "slurp gun" for Callianassa, large polychaete worms and whatever clams may be present; most of these items are used for bait. No persons were observed taking large numbers of Tapes for food.

Shellfish beds may be present in parts of the basin other than those sampled. Section 5, adjacent to the Hunters Point Shipyard fence, appears to have suitable habitat, but no close observations were made, and no fishing activity was seen there. Fishing was observed at Section 6, the small reservoir at the end of the intake siphon, and the substrate appears suitable for Tapes, but no empty shells or evidence of digging was seen. Tidal differences may be reduced in this reservoir, thus reducing the size of, as well as access to, clam beds. Section 8, along

the new fill line, has older riprap and stones in the outer portion on the south side, and dead shells indicate that at least some Tapes may be present; no sign of digging was found. The remaining areas appear unsuitable: Section 7 consists only of soft mud, and Section 9 is being filled at the present time.

In summary although a large shoreline of suitable habitat is available in India Basin, relatively few large Tapes or Mya were found in the areas sampled. The estimated population sizes of large Tapes and Mya are:

Section 2: $2 \times 160 = 320\ m^2 \times 50/m_a^2 = 16{,}000$ Tapes

$320\ m^2 \times 10/m_a^2 = 3{,}200$ Mya

Section 4: $2 \times 100 = 200\ m^2 \times 15/m_b^2 = 3{,}000$ Tapes

a) beach front only; based on sample C-2-2

b) beach front only; based on mean of samples C-3-1 and C-3-2

D. YOSEMITE CHANNEL

Yosemite Channel (fig. 5) is a narrow inlet of South Basin, an embayment located on the south side of Hunters Point. At minus tides it is drained completely except for runoff flowing down a small channel in the center of the inlet. Two wet weather outfalls empty into Yosemite Channel, one at the extreme western end off Yosemite Avenue, and the other midway along the north shore of the channel at the foot of Griffith Street. A pipe anchored in the mud by piles traverses the channel just east of this latter outfall. A third outfall is located just south of the mouth of the Channel proper. Two wrecked cars lie partially buried in the mud in the western portion of the channel.

The sides of the channel are lined by a variety of materials, only some of which contain shellfish. The northwest section

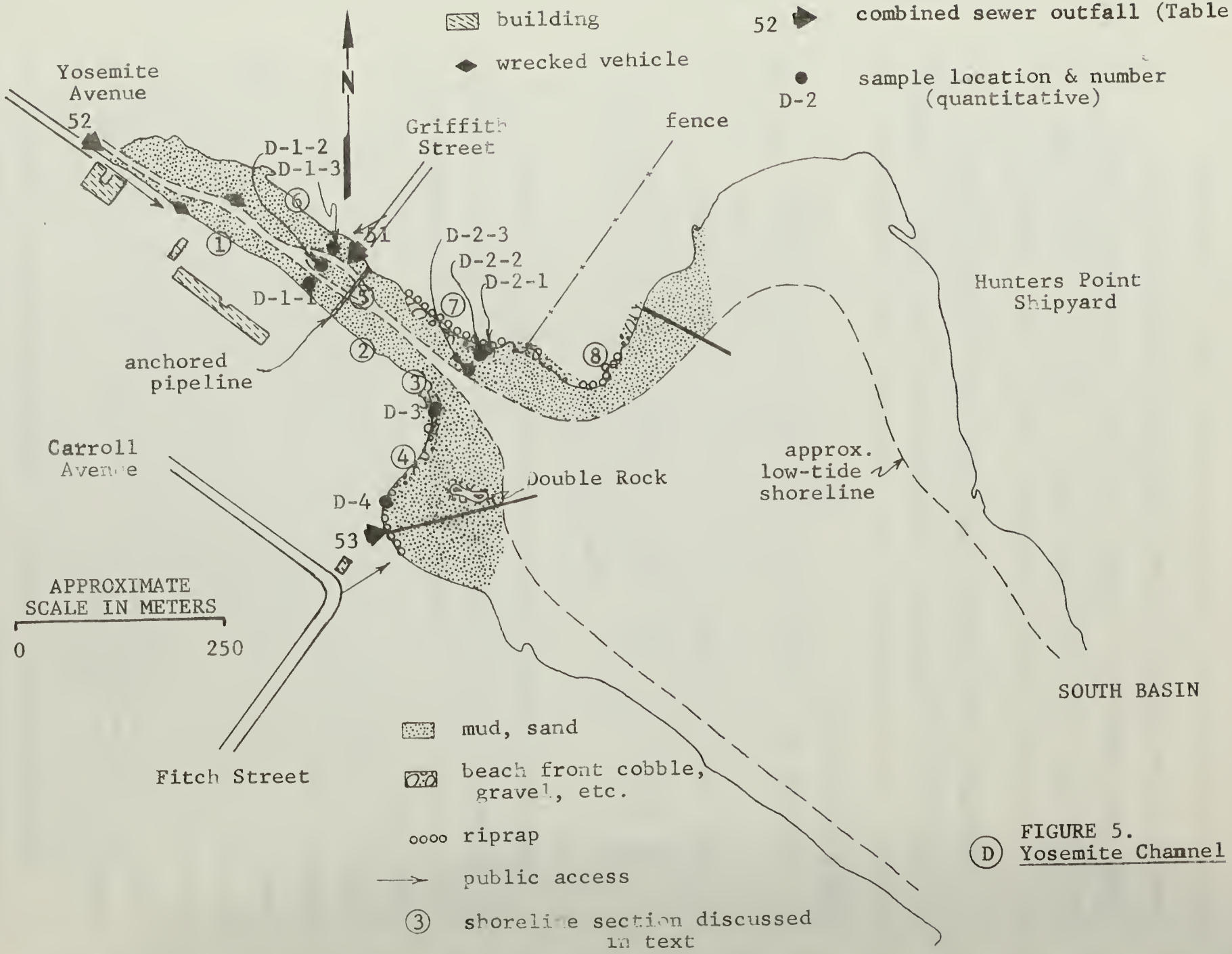

FIGURE 5.
(D) Yosemite Channel

(Section 6) is lined with mud banks, pickleweed (Salicornia), and with various types of junk; the southwest section (Section 1) is lined with asphalt blocks and rubble. Neither section has any shellfish. Further east on the south shore, Section 2 is lined by bricks, grading into rock and gravel at the tip of the channel (Section 3). Only a few Tapes were found in the bricks, but large numbers were found at the tip (see below). The northeast section (Section 7) has cobbles and gravel below large riprap, and supports a large Tapes population; this bed declines to the west nearer the outfall as the substratum becomes more sandy and drier.

The other important feature of the channel is an "island" in the center portion of the channel (Section 5), formed by a bifurcation of the drainage channel. West of the pipe the island is mainly mud, and supports a small population of large Tapes and Mya; east of the pipe the substratum is largely bricks and broken rock, with a few Tapes.

Two transects of three samples each were made in the channel, plus single samples in Sections 3 and 4. One transect crossed the western portion of the island, approximately 50 meters west of the pipe; the other crossed the Tapes bed in Section 7, about 40 meters west of the Hunters Point fence. The island transect included mud samples on either side of the channels, which yielded only small Mya. The sample on the island (D-1-2) yielded one large Tapes and two large Mya. Estimates of the populations of large Tapes and Mya on the western portion of the island are:

Section 5: $4 \times 50 = 200\ m^2 \times 10/m^2 = 2{,}000$ Tapes

$200\ m^2 \times 20/m^2 = 4{,}000$ Mya

Section 7 has a 2-3 meters wide bed of Tapes; spotchecking beyond the fence showed that this bed extends along the fill area east and north of Yosemite Channel for 300 meters or more. The numbers decline only at the tip of this fill (Section 8), where the riprap is larger; a substantial population of large Mytilus was found here. The full extent of the penetration of the Tapes bed into Hunters Point (Section 8) was not determined. As noted above, the Tapes bed declines and ultimately disappears further west in Yosemite Channel although some large specimens of both Tapes and Mya were found just east of the Griffith Street outfall (#51). Estimates of the populations of large Tapes and large Mya on the north side of Yosemite Channel is as follows:

Section 7: $3 \times 130 = 390\ m^2 \times 110/m^2_a = 42{,}900$ Tapes

$390\ m^2 \times 10/m^2_a = 3{,}900$ Mya

a) based on sample D-2-1

Section 8: $3 \times 170 = 510\ m^2 \times 200/m^2$ (estimate) = 102,000 Tapes

The south tip of the channel (Section 3) is a small rock pile with brick on either side. The bed contains both large Tapes and large Mya; estimates of the populations are:

Section 3: $1.5 \times 80 = 120\ m^2 \times 160/m^2_a = 19{,}200$ Tapes

$120\ m^2 \times 40/m^2_a = 4{,}800$ Mya

a) based on sample D-3

South of Yosemite Channel the bank (Section 4) is lined with bricks and sand over dense black clay for approximately 100 meters. A sample taken here (D-4) revealed a small population of Tapes. An estimate of the number of large Tapes is:

Section 4: 1.5 x 100 = 150 m^2 x 20/m^2 = 3,000 Tapes

A short sand beach follows, and the fill line turns 90° to a northwest-southeast line. The Fitch Street wet weather outfall (#53) is located here. No shellfish were found in this rocky fill.

Access to Yosemite Channel is relatively good; although the surrounding property is private, roads intersect the channel at two points. The Mya bed in Section 5 and the shoreline below Griffith Street appear to have been worked over extensively; evidence of limited digging was seen along the south shore. Interviews with a worker at the fill area on the north shore (Section 7) indicated that he was familiar with the area and knew about clamming for Mya, but was totally unaware of the large Tapes bed there. A person at the lumber company on the south shore reported that the channel had large populations of mussels 20-25 years ago. These have totally disappeared except for the population on the Hunters Point property (Section 8).

With regard to the latter, it is possible that the fence (and former Navy security) has precluded harvesting in the area, and so permitted the Tapes and Mytilus beds to thrive. Although the fence is old and easily circumvented at low tide, there was no sign of clamming activity on the property. No fishing activity was observed in the Yosemite Channel area; one person was seen taking clams for bait. It was not determined whether the disturbed area around Griffith Street resulted from searches for bait (clams, shrimp, worms, etc.) or from harvesting clams for food.

Digging of sample D-1-2 in the island released an oily substance from the sediment. The mud flats along Section 7 were covered with a layer of Enteromorpha, a long, stringy green alga.

E. SOUTH BASIN

South Basin (fig. 6) is the large embayment into which Yosemite Channel empties. It is bordered on the north by Hunters Point and on the south by Candlestick Point. The length of shoreline included in South Basin, for the purposes of this report, runs from the Fitch Street outfall east and then south to the northern end of a parking lot on the north side of Candlestick Point, adjacent to a pile of wrecked vehicles. Just off the mouth of Yosemite Channel is Double Rock, a natural rock outcrop examined in the preliminary survey; it was not revisited. Because of the length of shoreline involved, descriptions and populations estimates will be considered sequentially from Yosemite Channel.

The long line of fill extending southeast from the outfall for a length of approximately 850 meters (Section 1) is composed of steep banks of large concrete block riprap above sand and shells; this section is rather devoid of shellfish. The only break in the bank is a sand and mud beach (Section 2) about one-third the distance along the fill line, which includes a tide pool and pickleweed (Salicornia). Numerous old tires have been dumped here; some polychaetes were found in the mud (E-1). Extensive odorous seepage was observed along this stretch of fill.

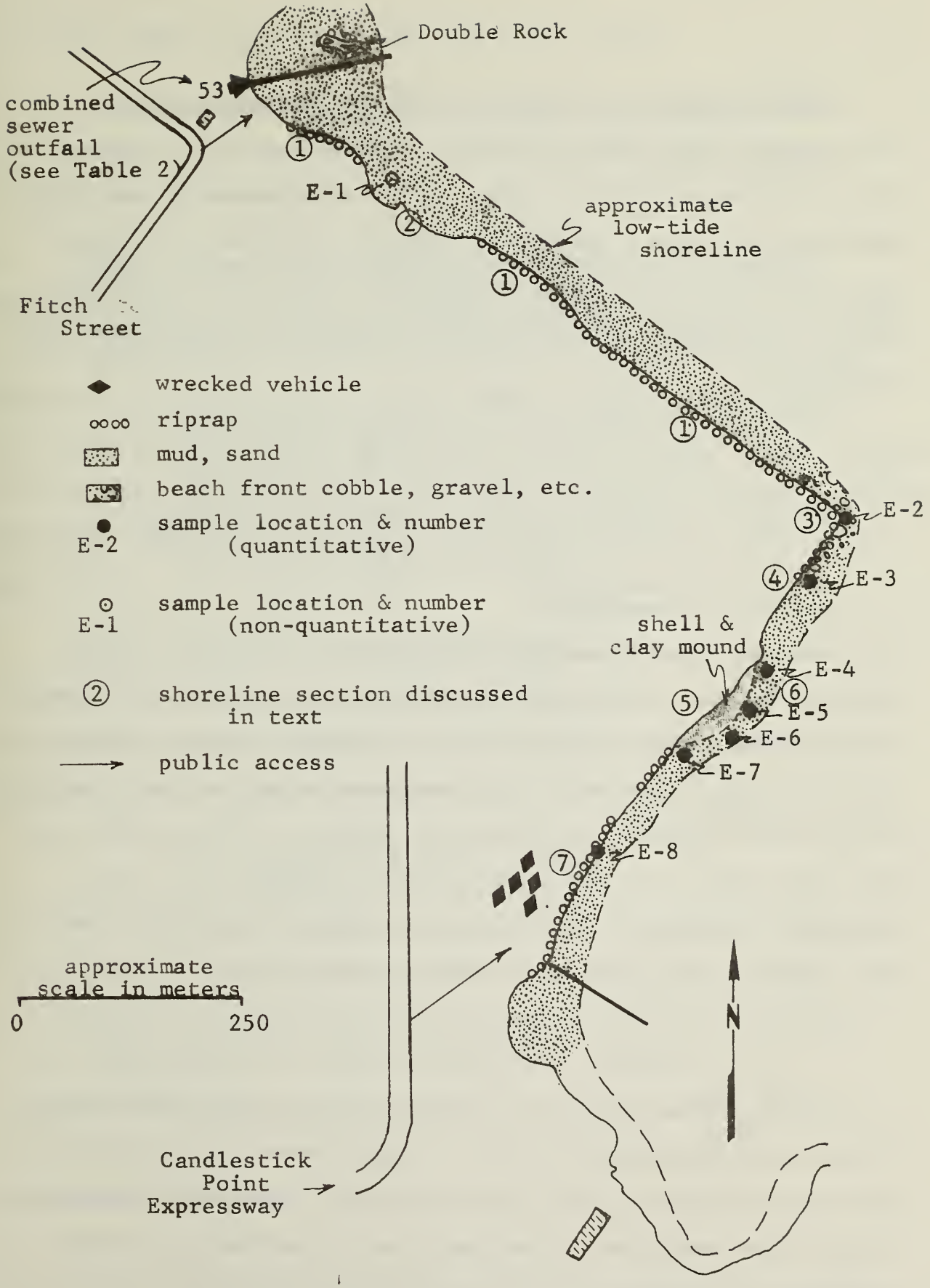

FIGURE 6.

(E) South Basin

The outermost 50-75 meters of the shoreline and 100-150 meters around the corner (Sections 3 and 4) consist of a beach front of rocks and cobbles which has a large population of Tapes, and some large Mya. The gravelly layer in Section 3 is thinner than in Section 4 and overlies sandy mud, so it has a somewhat smaller population. The estimates of numbers of large clams are as follows:

Section 3: $2 \times 75 = 150\ m^2 \times 30/m_a^2 = 4{,}500$ Tapes

$150\ m^2 \times 20/m_a^2 = 3{,}000$ Mya

Section 4: $4 \times 120 = 480\ m^2 \times 120/m_b^2 = 57{,}000$ Tapes

$480\ m^2 \times 10/m_b^2 = 4{,}800$ Mya

a) based on sample E-2
b) based on sample E-3

Section 3 marks the easternmost point of the fill section of South Basin, the shoreline of which turns and runs in a northeast-southwest direction for some 600 meters. South of Section 4 is a large bank composed of clay and shells (Section 5), with a broad beach of sandy mud (Section 6) below it, grading into the mud flat proper. In this sandy mud is a Zirfaea bed. It is difficult to estimate the size of this bed, but based on a mean of four samples (E-4, E-5, E-6, E-7) the estimate is:

Section 6: $10 \times 150 = 1500\ m^2 \times 7/m^2 = 10{,}500$ Zirfaea

South of the clay banks the shoreline is composed of dirt, large rubble and bricks (Section 7), with some cobbles below, but grading quickly into a broad mud flat. The brick layer, 3-4 meters wide, overlies sand and shells, and some clay. A heavy Ulva (sea lettuce) growth was noted on the mud flats.

No large Tapes or Mya were found among the bricks.

Odorous seepage was noted at several locations along the bank in Section 7, the southern border of which marks the end of the South Basin area.

Public access to this section of shoreline is somewhat difficult, but not overly so. Access is gained primarily adjacent to the Fitch Street area, from the parking lot near Candlestick Park, or by driving along the dirt roads in the fill area itself. Well-worn trails parallel the shore over much of its length. Fishing was observed at Section 3, and some evidence of digging, perhaps for bait, was seen in the mud at the beach in Section 2 and along Section 4.

Much of this area is being considered for incorporation into the Candlestick Point State Recreation Area (California Department of Parks and Recreation, 1978); the shoreline may be extensively modified from its present configuration.

F. CANDLESTICK POINT - NORTH

The shoreline included in this area is very complex because of the variety of fill materials which have been used in its formation, and because the point has been filled in at different times. The shoreline includes three parts (Figure 7): a southeast tending portion approximately 450 meters long, forming the west shore of a small cove; a northeast tending portion of approximately 200 meters length, which forms the east shore of the cove; and a second southeast tending portion out to the tip of the point, also about 200 meters long. A total of six single

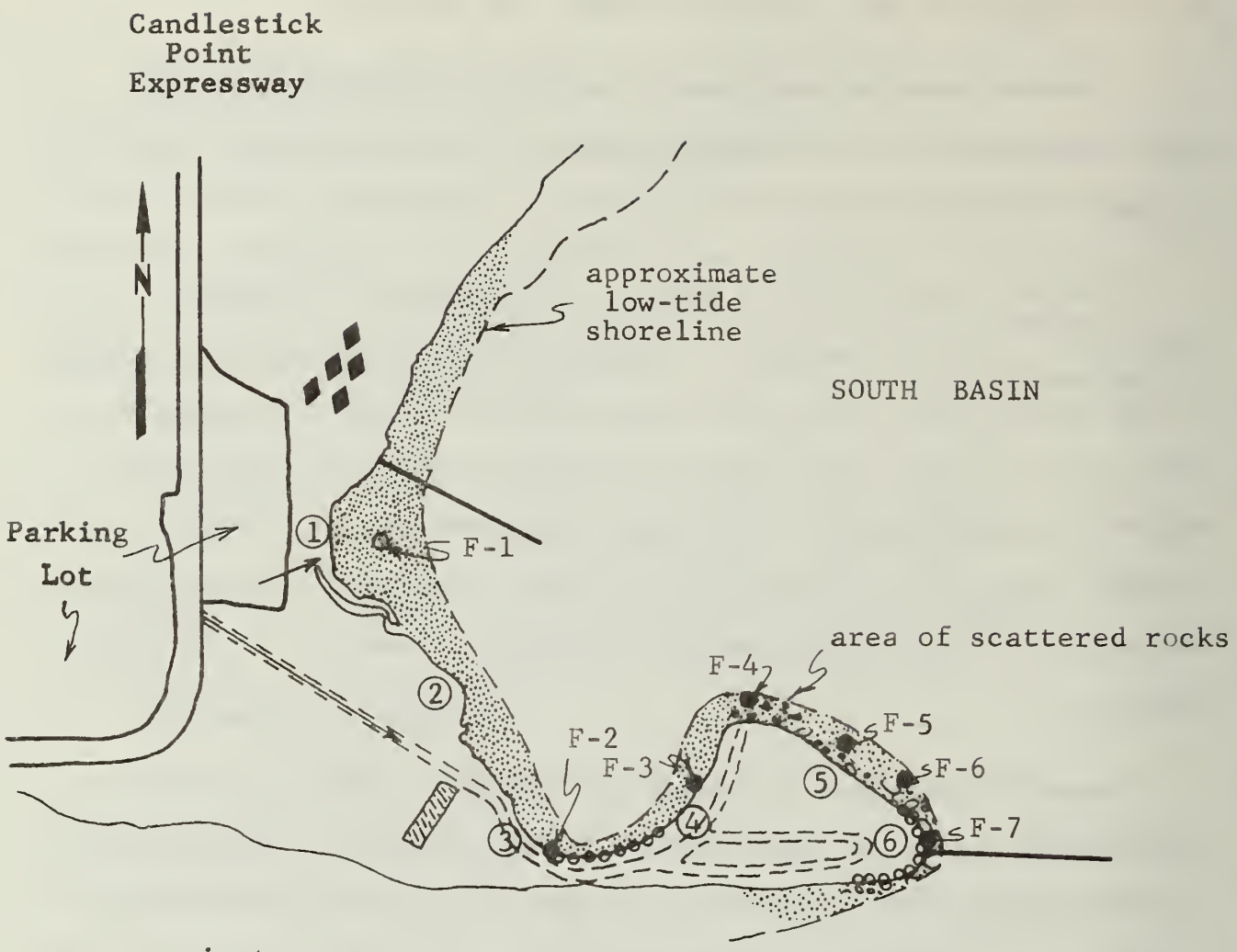

FIGURE 7.

(F) Candlestick Point North

quantitative samples were taken, plus extensive spotchecking.

A small indentation (Section 1) in the shoreline fronts a broad, sometimes soft and treacherous mud flat. Spot samples (F-1) here revealed the presence of large polychaetes and a few specimens of Mya and Macoma nasuta. Further southeast (Section 2) the shoreline is a complex mixture of shell beach, mud with broken shells, clay banks, and some stones, in overlapping and patchy distribution. Digging in the muddy clay exposed large complexes of burrows of approximately 2-3 cm diameter, running in all directions. These are probably made by the mud shrimp Upogebia; but since no specimens could be found this observation could not be confirmed. Tapes and large Mya are absent in both areas.

Section 3 is a muddy sand beach grading into mud flat below a dirt embankment. A sample taken here (F-2) included some small Tapes and Mya, plus a very unusual concentration of Cryptomya californica (Conrad, 1837), a small clam (up to 30 mm in length) which normally is buried in the mud and "taps" into the burrows of other infauna, such as Callianasa. Since extensive tubes were not observed in the substratum, it is possible that the substratum is porous enough for the clams to survive on the detritus in the interstitial water. This is the only concentration of Cryptomya found in the entire study. Some large Tapes are present in the riprap in this section.

The east side of the cove (Section 4) is a broad beach of gravel and sandy mud, grading into the mud flat proper. A sample

(F-3) contained very large numbers of small Mya (more than 3,000/m^2) and some small Tapes. The cove also contains many specimens of the large channeled whelk, Busycotypus. Although this gastropod was seen in other areas down to Sierra Point, the largest concentration was seen here. Cursory examination suggested that more than 20 specimens were present in Sections 3 and 4 alone; additional specimens were seen around the tip of the point.

The outer section of the north side of the point (Section 5) is composed of clay banks with scattered cobbles and a broad mud flat below the banks; the flat is very narrow at the tip. Sample F-6 contained one large and one small specimen of Zirfaea burrowed into the clay of the mud flat area, and a single large specimen was found in sample F-5. The extent of the bed is difficult to determine, but an estimate of the number of large Zirfaea is:

Section 5: 10 x 100 = 1,000 m^2 x 7/m^2_a = 7,000 Zirfaea

a) mean of three samples (F-4, F-5, F-6)

The tip of the peninsula (Section 6), with its broad rocky beach front covered with Ulva (sea lettuce) and red algae, below a steep riprap of large concrete blocks, appears to be an ideal habitat for Tapes and Mya. However, there is odorous seepage from the bank, and a sample (F-7) taken in the area contained almost no shellfish. Spotchecking showed few shellfish over most of the tip of the peninsula. The seepage may be a factor in the paucity of specimens, as observations from other areas also indicate that Tapes is reduced or absent in areas of odorous seepage, but not in areas where the seepage is clear and odor-free.

An estimate of the population of large Tapes on the tip of Candlestick Point (sample F-7) is:

3 x 50 = 150 m^2 x 10/m^2 = 1,500 Tapes

Public access is readily available here. Cars may be parked in the unfenced parking lot except on days of ball games, or even driven out onto the peninsula on a dirt track. The area is posted as state property in anticipation of the development of a state recreation area (California Department of Parks and Recreation, 1978), but the "No Trespassing" signs are largely ignored. Fishing activity was observed at the tip of the peninsula (and along the south shore; see below). Section 1 was extensively excavated, presumably to obtain worms and Upogebia for bait; some excavations were also seen in the isthmus area at the southern end of the cove.

In summary, the north side of Candlestick Point has limited sport potential, consisting of limited numbers of Tapes and Busycotypus, beds of Zirfaea, and various bait species.

G. CANDLESTICK POINT - SOUTH

The shoreline included here runs in a generally western direction from the tip of Candlestick Point around to the wet weather outfall (#54) alongside the Bayshore Freeway Candlestick Point off-ramp (fig. 8). The total length of the shoreline is about 2040 meters, and it includes a wide variety of substrata. The descriptions and estimates will be presented sequentially from east to west.

The outer portion of the south side of Candlestick Point (Section 1) presents a broad rock and gravel beach front below large concrete riprap, with a typical mud flat below the beach. Much of the beach was covered with Ulva (sea lettuce) during the sampling period. The width of the beach front varies from 2 to 7 meters, and the beach was found to hold a major Tapes bed.

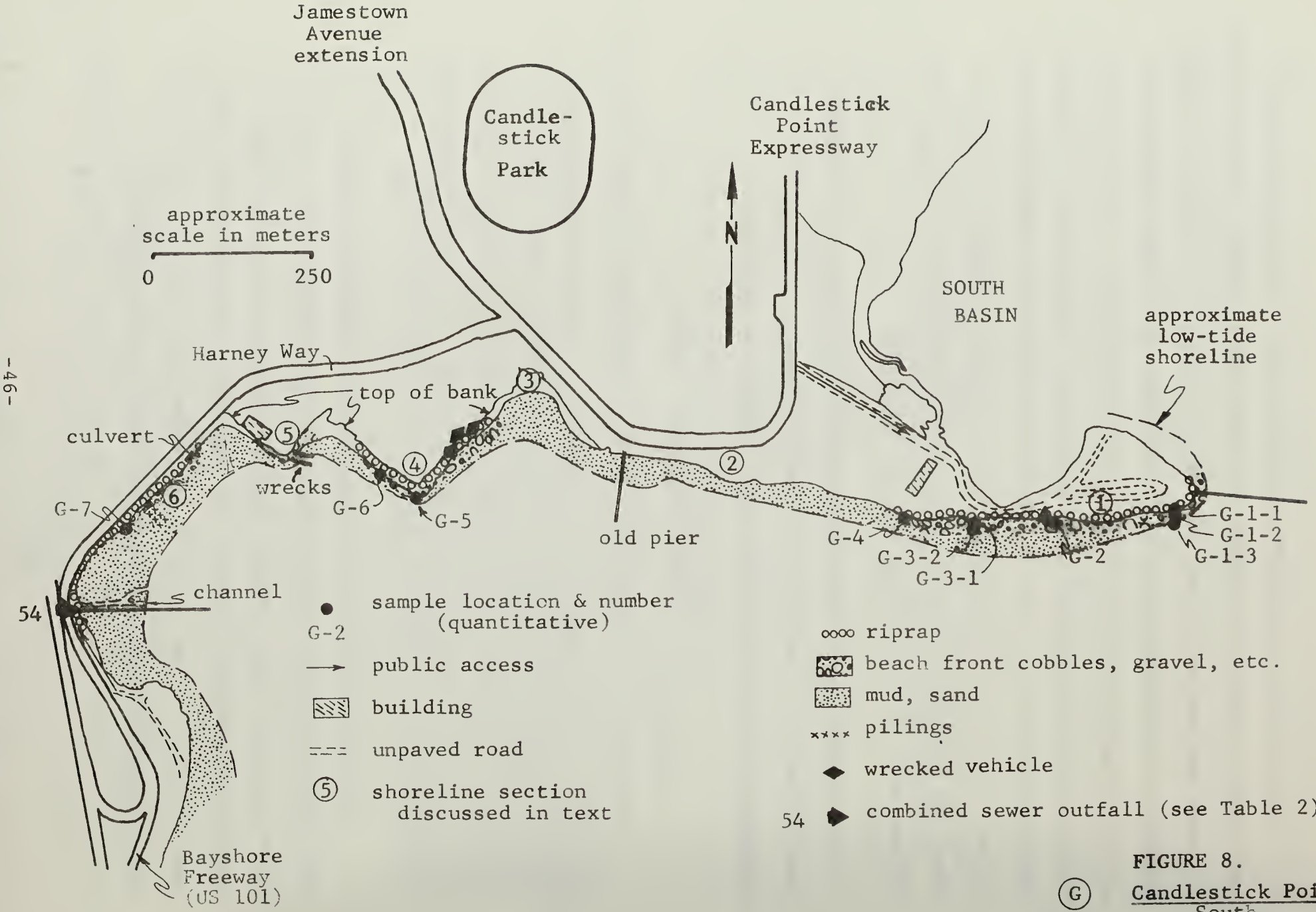

FIGURE 8.

(G) Candlestick Point South

A transect of three samples (G-1-1, G-1-2, G-1-3) was established approximately 50 meters west of the tip of the point. The upper sample (G-1-1), in sand and rocks, contained only one small Tapes and one small Mya. The middle sample (G-1-2) contained both large Tapes and large Mya, while the third sample (G-1-3) in the mud, produced only the usual crop of small Mya. Subsequent samples were taken in the beach front Ulva zone to determine the approximate length, width and density of the bed. Sample G-2 was taken near a wrecked car opposite the east shore of the small cove across the isthmus; combined with spotchecking, it revealed a bed approximately two meters wide in sand and gravel over clay.

Two more samples were taken about 70 meters east of an old building on the point, below a set of concrete steps used as riprap. The Ulva zone here was about 1.5 meters wide, and the samples (G-3-1 and G-3-2) were taken at the upper and lower edges of the algal carpet, respectively. The last sample (G-4) was taken a bit further west, south of the building, on a stretch which looked good for shellfish. Digging revealed a shallow layer of sand and gravel over dense clay, and only one small Mya was found. Thus the clam bed ends a short distance beyond the third set of samples.

Estimates of the numbers of large specimens in this section, assuming an average bed width of two meters, are:

Section 1: $2 \times 365 = 730\ m^2 \times 65/m^2_a = 47{,}450$ Tapes

$2 \times 120_b = 240\ m^2 \times 20/m^2 = 4{,}800$ Mya

a) density determined as mean of four samples (G-1-2, G-2, G-3-1, G-3-2)

b) approximate length of shoreline with Mya present (G-1-2)

As just noted, the shoreline changes near sample G-4; the beach front west of that point consists of dense clay banks above a broad beach front of gravel and rocks on sandy mud, which grades into the mud flat (Section 2). This terrain continues west for approximately 730 meters, terminating in a small cove with a sand and gravel beach above a wide mud flat (Section 3). No Tapes were found here, and only one large Mya near the old pier; however, a section just west of the old building, about 100 meters in length, contains a bed of Zirfaea, including some large specimens. The density and overall dimensions of this bed were not determined. Callianassa appears to be present in several sections, especially in the beach sands of Section 3.

The next section of shoreline consists of two V-shaped promontories; the larger one is a parking lot (Section 4), while the smaller has a machine shop operation (Section 5). Section 4 has a rock and rubble beach front of variable width (2 to 5 meters) beneath steep riprap; three wrecked autos lie on the beach. Two samples (G-5, G-6) were taken, and an estimate of the population of large Tapes here is:

Section 4: $2 \times 275 = 550\ m^2 \times 90/m^2_a = 49{,}500$ Tapes

a) mean of two samples (G-5, G-6)

The large rocks and concrete blocks in Section 4 provide a suitable habitat for moderate numbers of Mytilus, including large specimens, and some Ostrea. No estimate of the number of specimens there was attempted. The large flat rocks on mud also serve as nurseries for the plainfin midshipman, Porichthys notatus Girard, 1854. Nearly every large rock had a resident, protecting a set of several hundred eggs. Many of these eggs were developing in mid-July, and some larvae appeared ready to swim away. Although large numbers of midshipman are caught in Mexican waters by commercial fishermen, the fish has no local commercial value (Dustin Chivers, pers. comm.).

A small sand beach with many tubes, possibly of Callianassa, separates Section 4 from the smaller peninsula of Section 5, which consists of some cobbles and gravel over mud; a few Tapes were found here. The main feature is a large, dense population of Mytilus on the ribs and beams of two old hulks sunk into the mud; there are perhaps 10,000 large specimens here, though estimates are difficult. This is the largest population of Mytilus seen anywhere in the survey.

The last portion of Candlestick Point (Section 6) consists of steep riprap with a rocky and gravelly beach front, which grades into a sandy beach on the north end, and to mud flat on the south end, adjacent to the outfall. The center portion, about 200 meters long, has both Tapes and Mya. Estimates of the populations of large specimens based on one quantitative sample (G-7), are:

Section 6: $2 \times 200 = 400\ m^2 \times 30/m^2 = 12{,}000$ Tapes

$400\ m^2 \times 10/m^2 = 4{,}000$ Mya

Mya was very patchy in distribution, so the above number should be considered a general estimate only.

Public access to the eastern portion of the section is very good, as noted in the previous section. Although a road parallels the remainder of the shoreline, parking is not permitted, so access is limited. A few cars were seen parked at scattered spots on the shoulder of the road or at a fishing area just south of the outfall. Moderate fishing activity was observed, especially in the center portion of the shoreline near the Zirfaea bed and on the isthmus opposite the small cove. Some digging was observed in the Zirfaea bed, presumably only for bait. The bed in Section 6 has been heavily worked, quite possibly for food. The bed near the tip of the peninsula appears to be harvested only minimally, if at all.

Seepage was observed at several points, including at the tip of the peninsula, below the old building (this seepage had an oily appearance) and in Section 4. A small pipe a few meters south of the outfall emitted a variously-colored liquid; the flow was estimated at 10-15 liters per minute; this pipe is apparently a highway culvert.

H. CANDLESTICK CAUSEWAY

This area (fig. 9) includes the bay-side shoreline of the causeway carrying US 101 (Bayshore Freeway), and it measures some 3,300 meters in length, from the wet weather outfall to the north shore of Sierra Point. Most of the length consists of high banks of dirt and riprap; a beach front of cobbles, gravel,

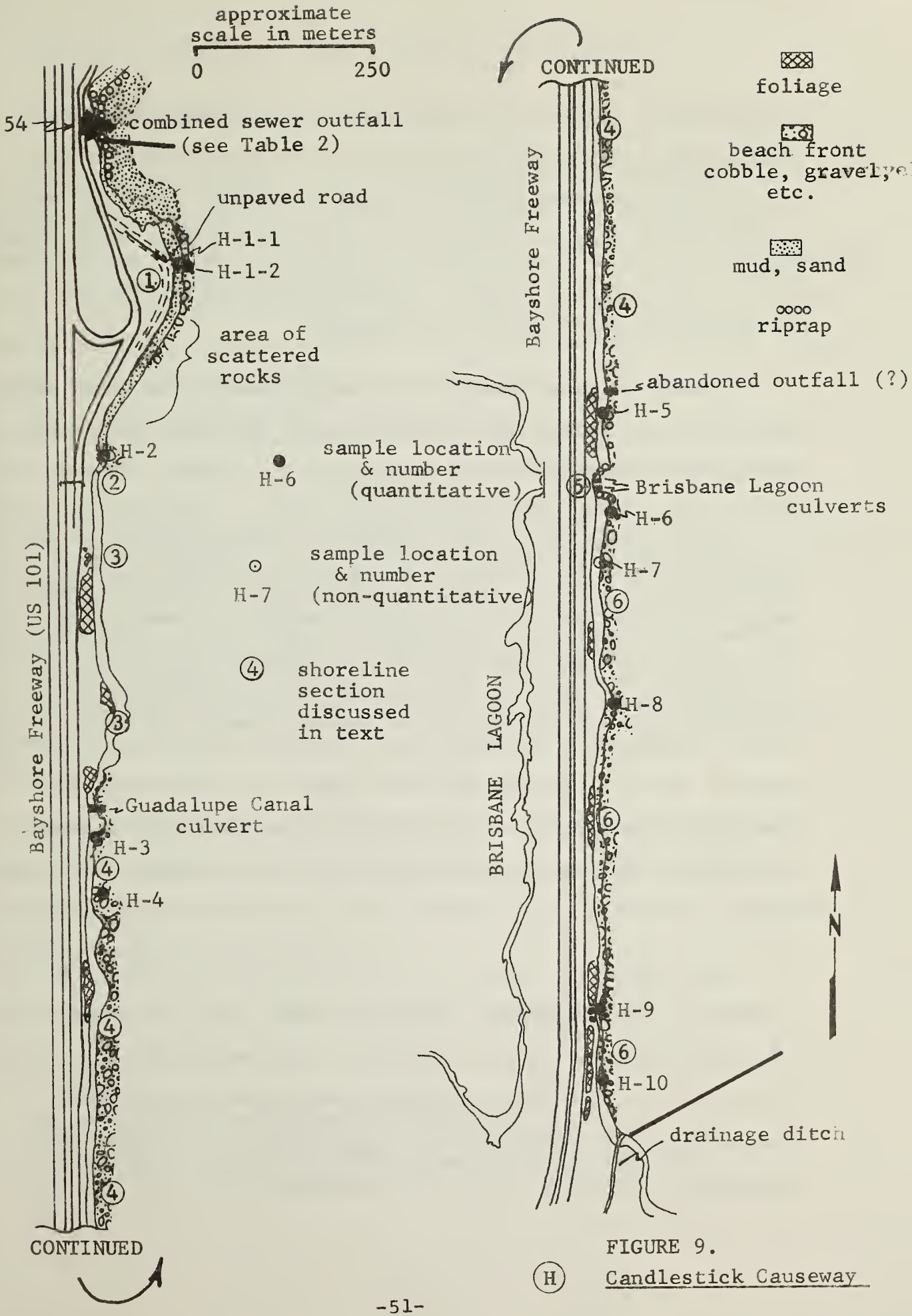

FIGURE 9.

(H) Candlestick Causeway

crushed rock, shells or clay banks; and the mud flats beyond. Occasionally the beach front extends out a short distance into the mud flat, forming small peninsulas or reefs. The only major break in this length of shoreline consists of a pair of 10 x 16 foot (3.0 x 4.9 m) rectangular culverts providing tidal flow to Brisbane Lagoon across the causeway.

A total of nine quantitative samples were taken along this shoreline; all were single samples except the first two, taken together on a transect.

The northern end of the causeway is expanded into the bay to provide space for the Candlestick Point off-ramp (Section 1). Much of the northern side of this peninsula is a shell bank; on the eastern side the midintertidal is composed of silt and cobbles over brown clay, with gravel and rocks on mud and shell further down. Samples on a transect here produced nothing in the middle portion (H-1-1), and only five small Tapes in the lower portion (H-1-2). Small Mya were common in the mud flat. The peninsula grades into clay towards its southern end; few or no shellfish may be found here.

Just beyond the south end of the peninsula, about 30 meters north of a sign structure over the freeway, there is a small area of concrete blocks on shell and mud, lying over dense gray clay (Section 2). Ulva and Enteromorpha were both growing there. One sample (H-2) contained many Tapes, nearly all small. An estimate of the population of large Tapes is:

Section 2: $7 \times 15 = 105 m^2 \times 10/m^2 = 1050$ Tapes

Only small Mya specimens were found.

The next section (Section 3) is composed almost entirely of clay banks in which no shellfish are found. This stretch is approximately 485 meters long and continues to a culvert for Guadalupe Canal, which drains part of Brisbane. South of this drain, the substratum begins to change to shell and sand above the mud, with several rock and rubble piles as well (Section 4). A sample near the edge of the mud flat in a substratum of shells, stones and mud (H-3) showed a density of large Tapes of about $120/m^2$ and of large Mya of about $20/m^2$. A small offshore rock pile (H-4) had a density of about 50 large Tapes/m^2, and spotchecking on the adjacent shore indicated a somewhat smaller number of large specimens were present there. Another sample, taken about 975 meters further south (H-5) between a large pipe (abandoned outfall?) across the beach front and the lagoon culverts, showed a higher density of large Tapes, approximately $160/m^2$.

The shoreline was similar along nearly the entire length of Section 4. Assuming an average bed width of 1.5 meters, and an average of approximately 100 large Tapes/m^2, the population estimates for this length of shoreline are:

Section 4: $1.5 \times 1{,}100 = 1{,}650\ m^2 \times 100/m^2_a = 165{,}000$ Tapes

$1.5 \times 120_b = 180\ m^2 \times 20/m^2 = 3{,}600$ Mya

a) mean of three samples (H-3, H-4, H-5)

b) estimated Mya area on north end of shoreline (H-3)

Section 5, immediately on either side of the culverts, is a steep riprap and rock bank with the tidal channel between. During flood and ebb there is a swift current here, and the flora and fauna on the banks reflect this current; sponges, tunicates, hermit crabs, barnacles, and red and green algae predominate.

South of the culverts (Section 6), the beach front is similar to that north of the culverts. This section extends for about 880 meters and terminates in a clay bank and drainage channel at the junction with the fill area of Sierra Point. Four quantitative samples taken at various locations along the shore indicated the presence of large numbers of Tapes, including large specimens, for the entire length. Large Mya were found only at the extreme southern end of the area.

The Tapes bed appears to be rather narrow in the northern portion of the area, perhaps 1-1.5 meters wide, and expands to as much as 3 meters closer to the southern end. Assuming a mean width of 2 meters, and densities determined as the mean of four samples (H-6, H-8, H-9, H-10), the estimated population sizes of large specimens are:

Section 6: $2 \times 880 = 1760\ m^2 \times 78/m^2 = 137,280$ Tapes

$1760\ m^2 \times 5/m^2 = 8,800$ Mya

Public access to the Candlestick Causeway is extremely limited at the present time, because parking is not permitted along the freeway shoulder except in emergencies (although some illegal parking does occur). The only exception is the small

peninsula at the north end of the causeway, where a small dirt road provides access to a very popular fishing area. This popularity may be responsible for the paucity of shellfish here, as the peninsula is extensively dug up, presumably for bait. However, evidence of some clamming activity was seen along the shoreline, especially south of the culverts. It is possible that access was gained by the same method as used by fishermen at the culverts: they are dropped off by car, and picked up later. Clamming activity, except at the north end, is still minimal, but plans to put a bikeway and fishing piers along the causeway may open this area up to exploitation (Environmental Science Associates, Inc., 1976). Access was further limited in December 1978, when the peninsula at the north end was posted with "No Trespassing" signs.

Seepage was minimal except for a clear, odorless seepage near the southern end.

I. SIERRA POINT

The area referred to as Sierra Point (fig. 10) is actually a large square fill area east of the original Sierra Point, a natural geographic feature (the eastern tip of San Bruno Mountain). The area above the tide line is still being filled, although the surface area is not being expanded. The approximate dimensions are: north shore, 500 meters; east shore, 625 meters; south shore, 550 meters. The area is nearly square except for a small extended fill area and drainage stream delta at the northwest corner of the point where it joins the Candlestick Causeway.

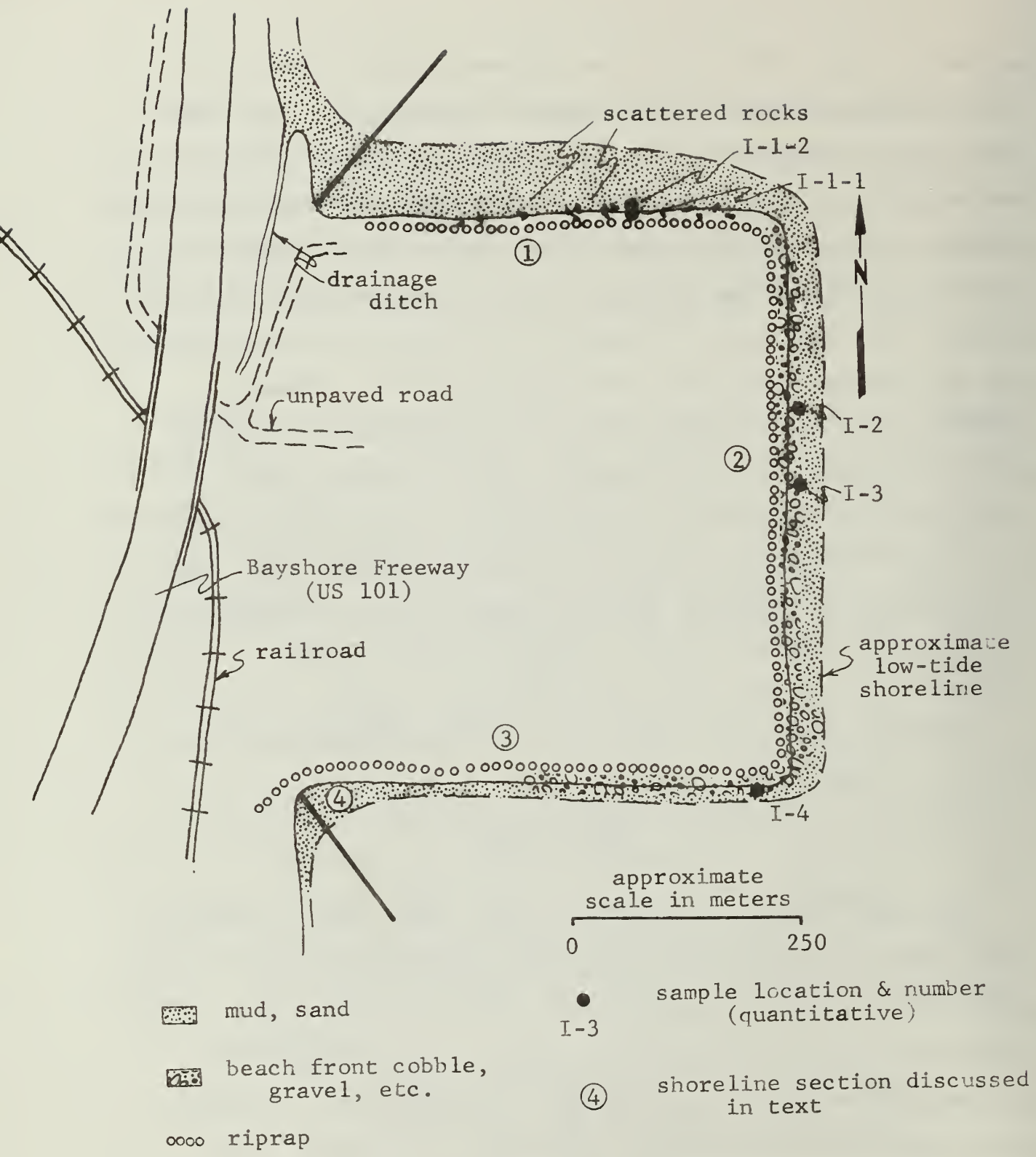

FIGURE 10.

(I) Sierra Point

The entire north shore (Section 1) of the point is steep concrete and iron riprap. The beach front below is narrow, consisting of a shallow layer of sand, gravel, mud and shells over clay. A broad mud flat extends out for some distance at low tide. A pair of samples on the beach front (I-1-1 and I-1-2, 1.5 meters above the mud line and at the mud line respectively), produced only small Tapes and Mya. The samples were taken about 330 meters out along the north shore.

The east (Section 2) and south (Section 3) shores are also bordered by riprap, but the beach front, composed of rocks, sand, mud and shell, is more suitable to Tapes. The area had a heavy covering of Ulva when sampled. Two single samples (I-2 and I-3, taken about 200 and 300 meters south of the northeast corner, respectively) contained large numbers of Tapes. The bed extends in a band 1-1.5 meters wide all across the east shore. Another sample (I-4) taken on the south shore about 40 meters west of the tip indicated that the bed continues along the south shore. Spot-checking along the south shore indicated that the bed is also 1-1.5 meters wide on this side. The bed declines and disappears in the western portion of the south shore, as the substratum changes. The southwest corner (Section 4) is a large muddy beach below huge concrete block riprap. No large Mya were found.

An estimate of the number of large Tapes along the east shore is:

Section 2: $1.25 \times 625 = 781\ m^2 \times 85/m_a^2 = 66{,}385$ Tapes

a) mean of two samples (I-2, I-3)

The number of large Tapes on the south shore is estimated as follows:

Section 3: $1.25 \times 275_a = 344\ m^2 \times 88/m^2_b = 30,272$ Tapes

a) half the length of the south shore

b) based on sample I-4

A few channeled whelks (Busycotypus) and some Mytilus, including a few large specimens, were found in the area.

The area is almost totally inaccessible to the public; the only access road is gated near the north end of Brisbane Lagoon. The only alternative is a long walk from Oyster Point to the south, across private property. No fishing activity or clamming evidence was seen anywhere on the peninsula.

A large development is planned for Sierra Point, which will include a large marina, townhouses, convention center, and stores. The topography of the fill area will be substantially changed, including a channel cut through a portion of the area. The development will connect to the bicycle paths and fishing piers planned for the Candlestick Causeway, and will ultimately connect to the Candlestick Point State Recreation Area (Environmental Science Associates, Inc., 1976).

Extensive odorous seepage was noted, especially along the north and east shorelines. Densities of Tapes decreased substantially in these seepage areas.

J. BRISBANE LAGOON

Brisbane Lagoon (fig. 11) is an enclosed body of water connected to the tidal action of the bay by two large concrete culverts. The lagoon is in the shape of a right triangle, bounded by the Bayshore Freeway on the east, the Southern Pacific railroad track embankment on the west, and a large fill area, covering an old garbage dump, on the north. Observations indicate that the culverts delay high and low tidal stages in the lagoon by 2-2½ hours, and a strong current is produced through the culverts during flood and ebb. The delay results in a slack period (no current) at low tide of only a few minutes.

Each of the three shorelines is quite distinct in composition. The east shore (Section 1) along the freeway, is about 975 meters long and bordered by a mud bank with Salicornia (pickleweed); the beach front consists of alternating sections of mud, shells, and occasional piles of rocks and gravel. Four single samples along the shoreline (J-1, J-2, J-3, J-4) contained both Tapes and large Mya. These species are not present in a continuous bed; rather, they are found in isolated patches where the substratum is suitable, particularly in the rock piles. The shell beds contain only a few small Tapes; the mud has large numbers of small Mya, but little else.

The first sample (J-1), taken just south of the culverts in a patch of rocks and gravel on mud, contained large Mya and small Tapes. The density of large Mya in the bed at the time of collection is approximately $70/m^2$.

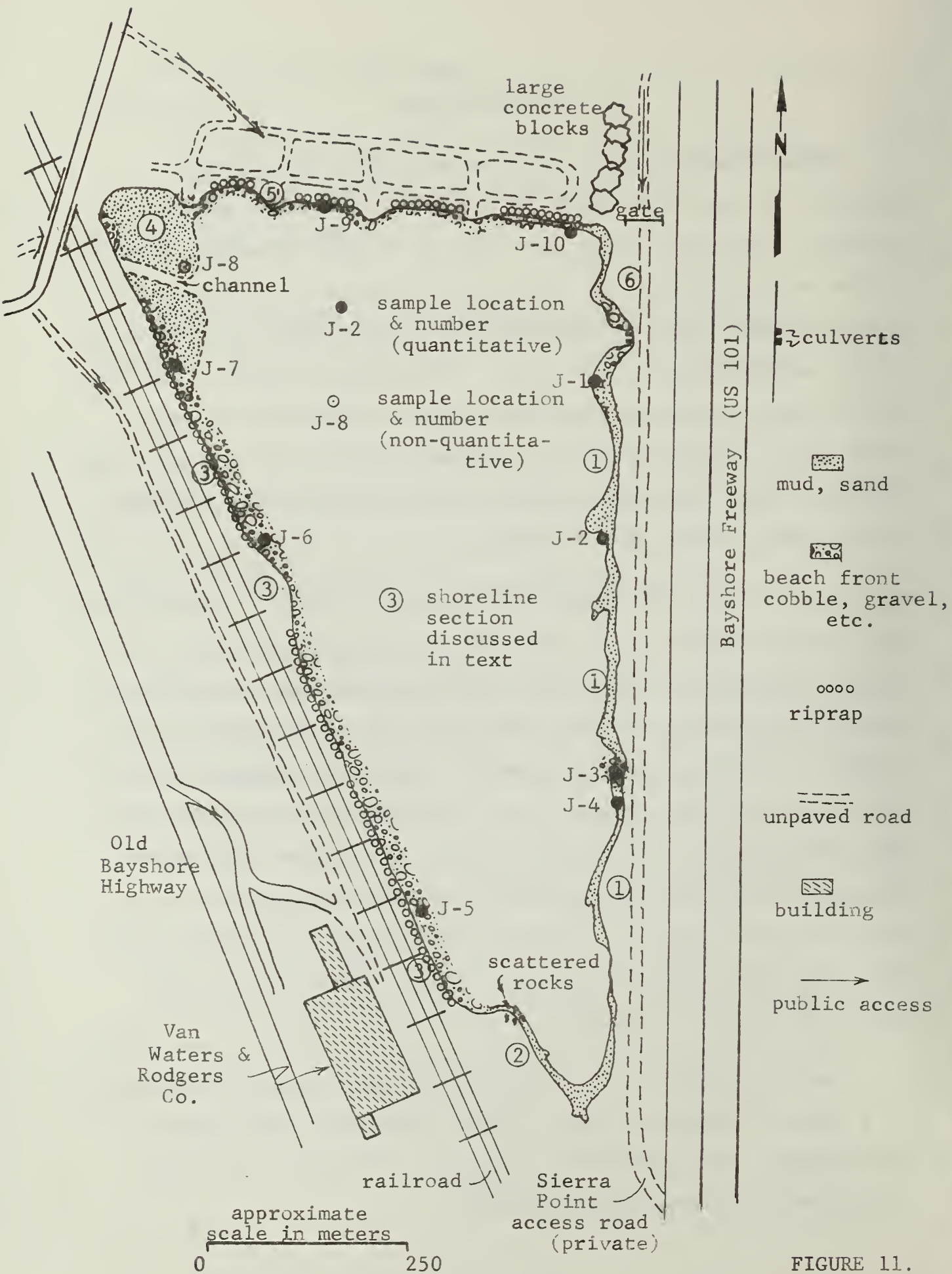

FIGURE 11.

(J) Brisbane Lagoon

A second sample (J-2), located just beyond a large shell bank some 240 meters south of the culverts, taken from an area of stones over gray mud, indicated approximate densities in that area of 80 large Tapes/m^2 and of 60 large Mya/m^2.

A sample in a rock outcrop (J-3) taken some 540 meters south of the culverts, have a density of 50 large Tapes/m^2 and of 15 large Mya/m^2. The rocks lie on dense gray clay, and many of the Mya specimens were dug out of this clay. The last sample from the east shore (J-4), taken another 10 meters south of J-3, came from a substratum of a few rocks, plus shells and mud on clay. A large population of Tapes was found, including large specimens estimated at 144/m^2; only a few small Mya were recovered.

Because of the patchy distributions of the substrata, population size estimates are extremely difficult. Assuming that 10 percent of the shoreline is suitable substratum, that the beds are 2 meters wide, and densities for both species are the means of the four samples (J-1, J-2, J-3, J-4), the estimates of large specimens for Section 1 are:

Section 1: $97.5_a \times 2 = 195\ m^2 \times 68/m^2 = 13{,}260$ Tapes

$195\ m^2 \times 36/m^2 = 7{,}020$ Mya

a) 10 percent of length of shoreline

The southern tip of the lagoon (Section 2) consists of a broad mud flat below a shell beach; shell piles, mud, and scattered rocks continue north and west for approximately 200

meters until the shoreline intersects the railroad right of way embankment. A few mussels were found here as well as a few native oysters and the introduced eastern oyster drill, Urosalpinx cinerea (Say, 1822).

The western shore (Section 3) is about 1150 meters long and consists of a steep bank of large blocks, above a beach front of cobbles, broken rock, gravel and mud. This front is very narrow in the southern end (less than one meter wide), but expands further north. Below a small peninsula midway up the shoreline, the beach front is 10-15 meters wide. Near the northwestern corner of the lagoon, the beach front fades out into a large mud flat (Section 4) cut by a channel collecting runoff water from the surrounding hills.

Three quantitative samples, taken opposite the north end of the Van Waters and Rogers Company plant (J-5), on the north side of the small peninsula (J-6), and about 200 meters south of the northwest corner (J-7), established the presence of a major Tapes bed, as well as some Mya. Taking a mean density and bed width, the estimates for the numbers of large Tapes and large Mya in Section 3 are as follows:

Section 3: $5 \times 900 = 4{,}500\ m^2 \times 37/m_a^2 = 166{,}500$ Tapes

$4{,}500\ m^2 \times 17/m_a^2 = 76{,}500$ Mya

a) mean of three samples (J-5, J-6, J-7)

The northern shore (Section 5) is some 650 meters long. The beach front, a narrow band of rock, gravel and mud over clay, is backed by low fill and some larger concrete blocks. The shoreline is straight except for the protrusion of five small rock piles. The western end, part of the previously mentioned

mud flat, has no shellfish. Two samples were taken in Section 5, one between the middle (largest) rockpile and the next pile further west (J-9), and a second about 30 meters west of the northeast corner (J-10). Estimates of the population sizes of large specimens in Section 5 are:

Section 5: 1 x 550 meters = 550 m^2 x 65/m_a^2 = 35,750 Tapes

550 m^2 x 45/m_a^2 = 24,750 Mya

a) mean of two samples (J-9, J-10)

The short length of shoreline between the northeast corner and the culverts (Section 6) is mostly clay, mud and shells, and has few shellfish.

The mud banks along the drainage channel in the northwest corner have a population of Mya; because of the consistency of the mud it was impossible to determine the extent and density of this bed. Unusually large specimens of Macoma balthica (up to 35 mm long) are scattered in the mud flat (J-8).

Public access to Brisbane Lagoon is readily available from access roads along the railroad tracks, along the northern shore, and down the Sierra Point access road to the gate. The culvert area, north shore, and entire west shore have been very heavily worked over by clammers. Some digging was also seen along the banks of the runoff channel. Extensive fishing activity occurs around the culverts and along the north shore.

Seepage was noted at several points around the lagoon. Sample J-3 was taken in an area of seepage, but the water appeared clear and odorless, and many Tapes were found there. The banks of the

northwest corner seeped an oily liquid; a light oil film could be seen on the mud flats and on the water; a distinct oily odor was noticed in the area.

VI. SIZE AND UTILIZATION OF SHELLFISH RESOURCES

When considering the size of the shellfish resources discussed in this report, it is important to remember tha tthe data presented are based on a few quantitative samples taken on one or at most a few days, augmented somewhat but nonquantitative spotchecking, repeat visits and observations of types of substratum present. In addition, because of the patchy nature of the distribution, extrapolation from one location to another on the basis of a few examples may be undertaken only at some risk. Therefore, the data must be viewed as a general estimate of the location and size of the standing crop of shellfish in summer 1978. The results indicate that several areas along the shoreline potentially contacted by wet weather overflows have large shellfish beds with sport shellfishery potential, particularly in regard to Tapes. There is less potential for Mya, and almost none for Zirfaea or Mytilus in the areas examined. The two last named species are sufficiently limited in numbers and distribution that even moderate sport shellfishing pressure might rapidly deplete the populations.

An examination of the Tapes data suggests that recruitment is occurring in most beds, because of the numbers of small specimens present. Work by Niesen (unpublished) on a bed near the San Mateo Bridge suggests that Tapes may reach legal size between its second, and third year, and that the largest specimens may be four years old. There has also been extensive recruitment of Mya this year, although only a small percentage may survive to reproduce due to predation by fish and shorebirds.

Two factors must be considered in connection with the sport exploitation of these beds. The first, health aspects, was not examined in the present study. There are many unanswered questions relative to bacteriological, viral and chemical contamination. The California Department of Health Services recommends against the taking of Bay shellfish for human consumption. Their concern is based upon the year-around possibilities of bacteriological contamination from non-point sources (e.g. boat wastes) or sewage treatment plant malfunctions, and the seasonal problems of bacteriological contamination from storm drains and wet-weather overflows (winter) or paralytic shellfish poisoning (May to October).

In order to quantify the existing bacteriological quality of the beds covered by this survey and to determine the effects of wet-weather overflows on the bacteriological quality, a bacteriological monitoring program for these beds was instituted by the Wastewater Management Program during August of this year. The results to date support some of the concerns of the health authorities in that 14 out 26 of the samples had fecal coliform levels in excess of the Food & Drug Administration standard of 230 MPN/100 grams shellfish tissue.

The second consideration is the extent of the present sport shellfishing activity in the areas studied. Most areas with any public access at all show some evidence of shellfishing activity, most often perceived as large holes in the mud or long shallow

trenches in the beach fronts. It is probably that in most of these locations the clams are being taken for bait; this is most evident in such areas as Islais Creek, India Basin, the south side of Candlestick Point, and the north end of the Candlestick Causeway (small peninsula). The effects are evident in the absence of large specimens of Tapes and Mya in those area as compared to unexploited areas, such as Sierra Point. The larger clams, and probably many of the smaller sublegal sizes as well, are regularly removed from the population; as a result, the percent of adult specimens in such areas is often lower than in unexploited areas with similar densities, as shown in Table 4.

TABLE 4

COMPARISON OF POPULATIONS OF TAPES
FROM EXPLOITED AND UNEXPLOITED AREAS

EXPLOITED AREAS	SAMPLE	#/0.1m^2	% LARGE SPECIMENS
Warm Water Cove	A-3	36	8.3
Islais Creek	B-1	6	0.0
	B-2	11	18.2
India Basin	C-2-2	54	9.3
	C-3-2	89	3.4
UNEXPLOITED AREAS	**SAMPLE**	**#/0.1m^2**	**% LARGE SPECIMENS**
Yosemite Channel - North Shore	D-2-1	24	45.8
Candlestick Point South Side	G-1-2	15	60.0
Candlestick Causeway South End	H-1	25	32.0
	H-10	51	23.5
Sierra Point -	I-3	13	84.6 (sample hand dug)
	I-4	19	57.9

The pattern is not wholly consistent and percentages are affected by sample size, substratum suitability, how the sample was obtained (screened vs. hand dug) and other factors. A general pattern of higher percentages of large specimens in unexploited areas can be observed.

One area is being heavily overexploited by sport shellfishermen for use as food. Observations made during surveys of Brisbane Lagoon indicated that despite Fish and Game regulations and such popular audience articles as the Fishing and Hunting News (Creyes, 1978), both the minimum size limit (1.5 inches or 38 mm) and bag limits (50 in combination) are being ignored. An informal survey of approximately 15 clammers along the north and west shores of the lagoon suggests that most clammers have fishing licenses, but seem to be unaware of, or choose to ignore, the limits. Almost any clam larger than one inch, and many as small as 3/4 inch are taken. Further, some persons did not even know the difference between species; one group referred to Mya as "male" Tapes. Rough estimates based on the containers used (typically a five-gallon plastic bucket) indicate that takes of as many as 1000 clams in a single catch are not unusual. It was estimated that, in areas not previously worked over too badly, a single clammer could readily take well over 100 clams per hour, especially if sublegal specimens are included.

Repeated sampling in some areas permitted a rough illustration of overexploitation. The observations noted above were made 22 July 1978. At this time the density of large Mya was established in the area just south of the culverts (J-1) at approximately $7/0.1m^2$. Two weeks later, on 3 August, three persons had to dig for two hours in that area to find just 8 large Mya. Even given the fact that the tide was not as low, the number of Mya appeared to be substantially reduced. In addition, the beach front on the west shore was greatly disrupted, with large sections laced with large holes and long shallow trenches. A return visit in early

September showed that several areas had again been harvested, including the area south of the culverts. In particular, the narrow band of beach front along the north shore had been largely stripped of shellfish.

Interviews with some clammers indicate that they feel that they "don't come here often", but in reality this may mean once a month or more, especially if the low tides fall on a weekend. Clamming often appears to be a "family affair", with groups of four or more persons all working a section of shoreline. The lagoon is also subject to greater pressure than other areas because of its accessibility, and because the tidal delay provides more beach front exposure during daylight hours in summer.

Long trenches in other areas, such as along the Candlestick Causeway and in the bed at the west end of Candlestick Point, suggest that clams are possibly being taken for food from these areas as well.

VII. EFFECTS OF WET WEATHER OVERFLOWS ON SHELLFISH POPULATIONS

Large populations of both juvenile and adult shellfish are found in rather close proximity (50 to 100 meters) to wet weather overflow outfalls at Yosemite Channel and at the north end of the Candlestick Causeway. The character of the substratum, rather than the presence of the outfalls *per se*, appears to be the dominant factor affecting the distribution of shellfish in these areas. It is possible that the outfalls may have some very localized effects, such as increased detritus or temporary salinity changes, which could affect population size immediately adjacent to the outfalls. However the nature of such effects is unknown. With respect to *Mya*, the effect of the overflow may be beneficial, as several sources have reported that this species appears to prefer areas subjected to occasional fresh water discharges (Wooster 1968; Walt Dahlstrom, pers. comm; Thomas Niesen, pers. comm). These effects, if present, do not appear to play an important role in the distribution or density of species a short distance removed from the outfalls.

VIII. COMPARISON WITH PREVIOUS STUDIES

As mentioned briefly in the introduction, direct comparisons of densities, areal distributions, and species compositions between the present study and previous studies are difficult because of a number of factors which complicate such direct comparisons. First is the fact that the samples were not taken from exactly the same areas: as noted before, small differences in position, especially higher or lower on the beach front, can produce widely differing estimates of the numbers of clams present. The number of samples is limited in all of the studies: a comparison of data for the Candlestick Causeway area (the only area studied in common by Wooster (1968 a, b), the EPA (U. S. Environmental Protection Agency, 1974), and the present work) shows how limited the data are. Wooster's data consisted of seven samples, not all of which were quantitative, while the EPA data consisted of six quantitative samples.

The analysis and comparison between these studies is further complicated by several other factors. The original data for both studies has not been available; they are found in unpublished field and lab notes (kindly made available to the author). The samples chosen by the EPA from Wooster's data include some samples taken four months apart, and fout of the six EPA samples

are from an area not included in the selected Wooster data (the offramp peninsula area at the north end of the Causeway).

The results in the published EPA summary report do not reflect the results found in the Candlestick Causeway bed comparisons. Although the summary reported an overall 50% decline in total numbers of large specimens (reported as "angler" days, the number of clams divided by 50, the catch limit), the Causeway data indicate an increase of 21%. The summary report also noted a 42% overall decline in clam weight per unit area, and this was reflected in the Causeway data, which showed a 26% decline, a non-significant decrease (their analysis). However, this measure is suspect because it is based on wet weight (including shells), and is based on mixed samples with various proportions of Tapes and Mya. This method is less accurate than a comparison on a species-by-species basis, even if all of the other problems could be discounted.

Further complicating the analysis is the fact that the beds described by Wooster (1968b) are incorrectly plotted in the Jones and Stokes Associates Inc. report (1977: Figure A, p. 153). This may be due partly to some confusing descriptions in Wooster (1968b). However, such errors only compound the problem for future investigators. The actual and published locations of Wooster's beds 1-6, as well as the location of the EPA samples, are shown in Figure 12.

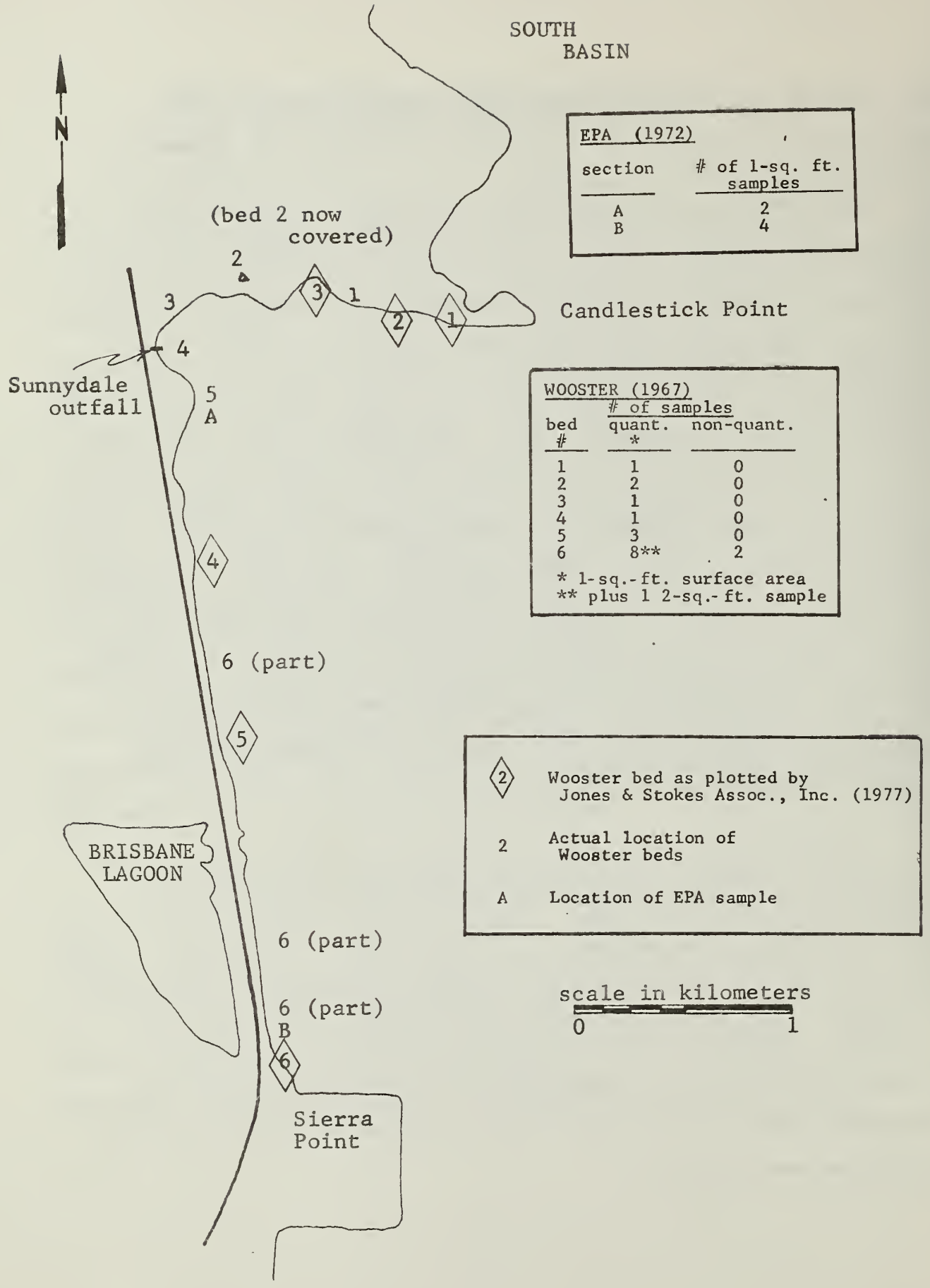

FIGURE 12.
Sample Locations

Given the limited opportunities for detailed comparative analyses, it may be stated nevertheless that data from the three studies indicate a general similarity in the distribution and areal dimensions of the beds during the past eleven years. The Jones and Stokes Associates, Inc. (1977) suggestion that all of these beds are either "defunct" or "possibly defunct" appears to be incorrect. Bed 1 is still extant to some degree, and the bed has increased greatly in size in the new fill area at the tip of Candlestick Point. Bed 2 is indeed defunct, since it has been filled, but clams are found in the areas of new fill. Bed 3 is heavily exploited, but still present. Bed 4, at the mouth of the Sunnydale outfall, was not sampled as there were no indications of large numbers of clams being present there. Bed 5 appears to be reduced substantially in the number of large clams present there, compared to both previous studies; this may be due to heavy pressure for bait, as well as for consumption. Bed 6, which actually consists of several sections along Candlestick Causeway, is still largely untouched, and includes a very large population of clams.

IX. SUMMARY

1. In the mud flats below MLLW juvenile Mya arenaria are ubiquitous with densities exceeding 2000/m^2 in some locations; however adult Mya are very scarce in these flats.

2. The Japanese littleneck clam, Tapes japonica, is the most common harvestable sized shellfish species observed in the survey area, with beds observed in Warm Water Cove, Yosemite

Channel, South Basin, the south shore of Candlestick Point, Candlestick Causeway, Sierra Point, and Brisbane Lagoon.

3. Harvestable-sized soft-shell clams, Mya arenaria; clams of the Macoma species; oysters, Ostrea; the rough piddock, Zirfaea pilsbryi; and the bay mussel, Mytilus edulis, were limited in distribution and low in density. Populations of these species are probably too low in the survey area to support extensive shellfishery activity.

4. Tapes, and to a lesser extent Mya, is heavily exploited in some areas, either for bait (Islais Creek, India Basin, north end of Candlestick Causeway) or for food (west end of Candlestick Point, Brisbane Lagoon). Population size class distributions and field surveys indicate that bag and size limits are largely ignored, and that some areas are subjected to overexploitation.

5. Distribution and densities of populations of shellfish species appear to be related more to the presence of suitable substrata than to the presence of the overflow outfalls, although the outfalls may affect substratum composition or other environmental factors in the immediate area of the outfalls.

ACKNOWLEDGMENTS

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APPENDIX A

PRELIMINARY REPORT

PRELIMINARY REPORT

SURVEY OF SPORT SHELLFISHING POTENTIAL IN SAN FRANCISCO BAY, IN SOUTHERN SAN FRANCISCO AND NORTHERN SAN MATEO COUNTIES

Prepared for the City and County of San Francisco Wastewater Management Program, under Grant Number C-06-1399-010, and DPW Order Number 111,979.

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16 June 1978

This report presents the results of a preliminary survey of intertidal areas along the west shore of San Francisco Bay, in southern San Francisco and northern San Mateo Counties, during the period 7-10 June 1978. The purpose of this survey was to determine areas which may have sport shellfishing potential, and which may be affected by wet weather combined sewer overflows. This preliminary phase was designed only to locate general locations of shellfish populations, not to make quantitative measurements of population densities or distributions.

Thirty stations were surveyed along the shoreline between the Oyster Point Marina and the Pacific Gas and Electric Company Hunters Point Power Plant, including four stations in Brisbane Lagoon (fig. 1). Most of the stations examined by Wooster (1968; his stations 1-7) were re-examined. Part of his station 7 has since been covered by fill, but the area along the new fill line was surveyed.

Examination of each station consisted of the following: general appraisal of substratum type; types and extent of shell debris, if present; type and distribution of algae; examination of hard substrata for presence and general size classes of Mytilus edulis, Ostrea lurida, barnacles, etc.; clearing and searching gravel substrata for presence and general size classes of Tapes japonica; digging in soft sediments for presence and general size classes of Mya arenaria, Macoma species, Callianassa californiensis, and other fauna; and notation of other relevant factors, such as seepage, other species, etc.

Some general comments are in order. First, the preliminary survey suggests that distribution and density of many of the species are very patchy, apparently in large part because of the heterogeneous nature of the substrata, resulting from different types of fill being dumped in adjacent locations. Local conditions are further affected by man-made structures and conditions, such as drainage ditches, culverts, seepage, and shellfishing activity. Thus it is inappropriate to extrapolate the size or density of a population beyond the area actually examined.

Second, most areas revealed extensive shell debris, especially large specimens of Macoma nasuta and Mya arenaria. However, large living specimens were rarely found. Extensive further investigation will be required to determine with accuracy the distribution and density of these species; it is possible that many of the larger shells are from subtidal populations. Small specimens of Mya arenaria (1-2 cm. shell length) were extremely common at most stations.

The results of the preliminary survey are presented in Table 1. Certain species present at virtually every station, such as Hemigrapsus oregonensis, have not been included.

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TABLE 1.

Station 1 - inside Oyster Point - public access area;

Pickleweed grading into mud flats with sunken barges, piles, shell debris;

Little fauna in pickleweed; small Mya specimens in mud; some large Mytilus (8-10 cm length) and Ostrea (2-4 cm length) on barge and piles; heavy barnacle set; very few small Mytilus

Station 2 - Oyster Point Harbor area - public access area;

Sandy beach grading into sandy mud; rocky bank and metal breakwater on north side; mixed sediments and shell debris present along breakwater;

One large Mya found on sandy beach - may be extensive bed in this area; live Tapes (legal size) and many empty shells in rocky area; few Ostrea on breakwater as well as large Mytilus further out

Station 3 - north bank of Oyster Point south breakwater

Rock riprap, with approximately 10 m wide sandy mud and broken rock flat, grading into mud flat

Extensive barnacle set and rocks covered with Ulva; dense beds of small Mya plus tubes from either large, deeply-buried Mya, or Callianassa (further investigation required)

Station 4 - Oyster Point fill area - north and east banks

Rock riprap along east and north shores; shell debris and thick gray mud on east shore; extensive shell debris on north shore, covered by thin layer of whole Macoma nasuta valves, 8-10 cm long

Few small Mya near surface of mud; very few Ostrea and Mytilus on rocks; few small Mytilus present

Station 5 - Sierra Point - south shore, about 2/3 way out along shore

Rounded gravel below rock riprap, grading into mud flats; heavy Ulva covering;

Heavy barnacle set; heavy Tapes bed in gravelly area; all sizes seen, including 15 or more legals in approximately 2 sq. ft. area; small Mya in mud

Station 6 - Sierra Point - east shore, about 3/4 way to southeast corner

Similar to 5: rounded gravel below riprap, mud flats beyond; heavy Ulva covering

Heavy barnacle set; very heavy Tapes bed; perhaps 10-15 per sq. ft.; all sizes from less than 1 cm to approximately 7 cm; Ostrea present, but only few Mytilus; small Mya in mud; one large Busycotypus found

Station 7 - Sierra Point - north shore, about 1/3 way out along shore

Large concrete rubble lying on sandy gravel; water and oil seepage seen; sand grades into mud flats; some Ulva present

Little present on shore except some barnacles; very heavy concentration of small Mya in mud

Station 8 - Bayshore Causeway - south end, where grades into Sierra Point

Broken rock grading into mud flats, with scattered rocky areas offshore; dense Ulva and Enteromorpha covering

Heavy barnacle set; heavy Tapes bed, all sizes present; Ostrea common, few scattered Mytilus; very few small Mytilus; some Mya in mud, mostly small; depressions in mud suggest working by fish or by shellfishers

Station 9 - Brisbane Lagoon - southeast corner

Mud banks bordering mud flats; mud thick, black, anoxic; small Mya 10-15 m from bank; also found one large Macoma nasuta (probably living);

Station 10 - Brisbane Lagoon - west shore, along RR tracks opposite VWR, Inc.

Very large broken rock riprap bank, smaller irregular and rounded stones grading into silty mud; scattered wire, scrap, and other junk

Barnacle set; Ostrea fairly common; found live specimens and extensive shells of Tapes; large Tapes bed reported in this area

Station 11 - Brisbane Lagoon - northwest corner

Rock riprap on north side, grading into thick, black, anoxic mud; oil seepage from bank, and oil sheen on water; firmer mud along drainage channel slightly further south

Nothing in mud along north shore; found adult Mya and Macoma balthica near surface in mud along drainage channel banks

Station 12 - Brisbane Lagoon - south side of culvert connecting to San Francisco Bay

Deep channel, with strong current, lined by rock and cobbles, grading into shell debris around corner from channel

Few specimens of small Tapes and Mya in substratum; red and green algae, hydroids, sponges, etc. on channel banks and lining culvert

Station 13 - Bayshore Causeway - bay side of culvert connecting to Brisbane Lagoon - south side

Rocky area with deep channel; fast current;

Area similar to protected outer coast; sponges, hydroids, red and green algae; hermit crabs, etc.; some small Mytilus attached to rocks

Station 14 - Bayshore Causeway - about 2/3 way to north end

Riprap and cobbles grading into mud flats; similar to station 8 in general substrata

Tapes present in stony areas, but populations sparser than at station 8; small Mya in mud offshore

Station 15 - Bayshore Causeway - north end, opposite exit ramp to Candlestick Park

Heterogeneous area: Salt ponds, shell debris windrows, stony and shelly beach of various consistencies, grading into mud flats with scattered rocks, etc.; Ulva on rocks and Enteromorpha on mud flats

Patches of legal Tapes mixed with large Mya (5-7 cm length) in beach areas; taper out further south as substratum changes; Mytilus and Ostrea sparse and patchy on shore and on offshore rocks; many small Mya in mud; larger holes may be Mya or Callianassa; heavy barnacle set on offshore rocks; one large Busycotypus found; Ilyanassa scattered on mud flats

Station 16 - Candlestick Point - south shore, west of old fishing pier

Rubble and sand grading into mud flats, with broader mud flats in small cove to east, nearer to pier

Occasional large Mytilus on larger rocks; only few small Mytilus seen; Tapes, if present, poorly represented; heavy barnacle set; small Mya and Upogebia (?) common in mud

Station 17 - Candlestick Point - south shore, on neck opposite cove on north side of point

Stones, gravel and rubble grading into mud flats

Heavy Tapes bed; all sizes collected, including about 10 legal-sized specimens from 2 sq. ft. area; similar to Sierra Point beds; small Mya in mud flats

Station 18 - Candlestick Point - eastern tip

Rocky area with soft, black mud; heavy Ulva covering, seepage from fill area

Little present except barnacles

Station 19 - Candlestick Point - northeast shore

Dense, sticky, gray mud beyond area of mud mixed with small rocks and stones

Many small Mya in mud, plus larger siphons (4-6 cm. long, 1.5 cm. diameter) attached to small specimens of burrowing pholad, probably Zirfaea; one large Busycotypus seen.

Station 20 - Candlestick Point - cove on north shore

Soft sand grading into mud

Many small Mya plus good population of Upogebia(?); bed may continue all across cove

Station 21 - South Basin - southside - small cove about 1/3 way along north shore of fill area.

Sand and rubble grading into soft mud; much shell debris

Mainly small Mya in mud; evidence of digging on mud flats; not known what was taken

Station 22 - South Basin - southwest corner - outfall at end of Fitch Street

Brick, rubble, junk on shore, grading into very soft mud flats

Little present except barnacles on hard objects and some small Mya in mud

Station 23 - Double Rock in South Basin

Sandstone outcrop (two formations) surrounded by soft brown mud flats

North side of rock has mixed population of large Mytilus, large Ostrea (2-4 cm. length), and Tapes; no large populations of any of these species; large barnacle set; surrounding mud has small Mya and scattered Ilyanassa

Station 24 - Yosemite Channel in South Basin - north shore adjacent to Hunters Point fence

Stones and sand in bank grading into mud flats

Large Tapes bed on bank; approximately 10 per sq. ft., including 5 legal-sized specimens; bed tapers out to west, and disappears by Griffith Street; observation of cove on Hunters Point property suggests that bed may continue for some distance to east, but needs to be checked; extensive Tapes shell debris present; some small Mya in mud; mud flats extensively dug up; one Ischadium demissum found attached to small rock

Station 25 - Yosemite Channel in South Basin - middle of channel in drainage area, opposite Griffith Street outfall

Drainage channel of firm mud and extensive shell debris between banks of softer, fine mud; area crossed by pipe with pile of brick and rubble just east of pipe

Bed of large Mya in mud banks adjacent to channel just west of pipeline; buried shallowly in mud; extent not determined; larger bed of small Mya surrounds large specimens; extensive shell debris present; scattered Tapes in brick pile, and barnacles and occasional Mytilus on rocks, pipe anchors, etc.

Station 26 - Yosemite Channel in South Basin - north side, west of Griffith Street

Pickleweed on banks, with rock rubble, extensive junk, with very fine mud in channel area

Barnacles on hard substrata, but little else

Station 27 - Yosemite Channel in South Basin - west end, at Yosemite Avenue outfall

Pickleweed above soft mud, with drainage channel of firmer mud and extensive shell debris; much junk

Little present except barnacles

Station 28 - India Basin - small landing area between power plant and boatyards

Rock riprap, with mud flats extending out from it

Good population of Tapes in rocky bank; all sizes seen; 5 legal-sized specimens per 1.5 sq. ft. area

Station 29 - India Basin - shore area between small landing and power plant Unit #4 cooling water outfall

Mud flats and stony and sandy areas, with drainage channel meandering through mud flats; extensive shell debris

Small Mya in mud, plus large polychaetes (probably Neanthes); Tapes scattered throughout sandy and stony areas, and many shells seen; area used for bait by fisherman in area

Station 30 - India Basin - cooling water channel from Unit #3

Mud flats covered by thick layer of diatoms, forming mat

Tapes common, lying on mud under diatom mat; most appear to be approximately 2 cm long; density approximately 3-4 per sq. ft.; unusual to see this species in such a substratum

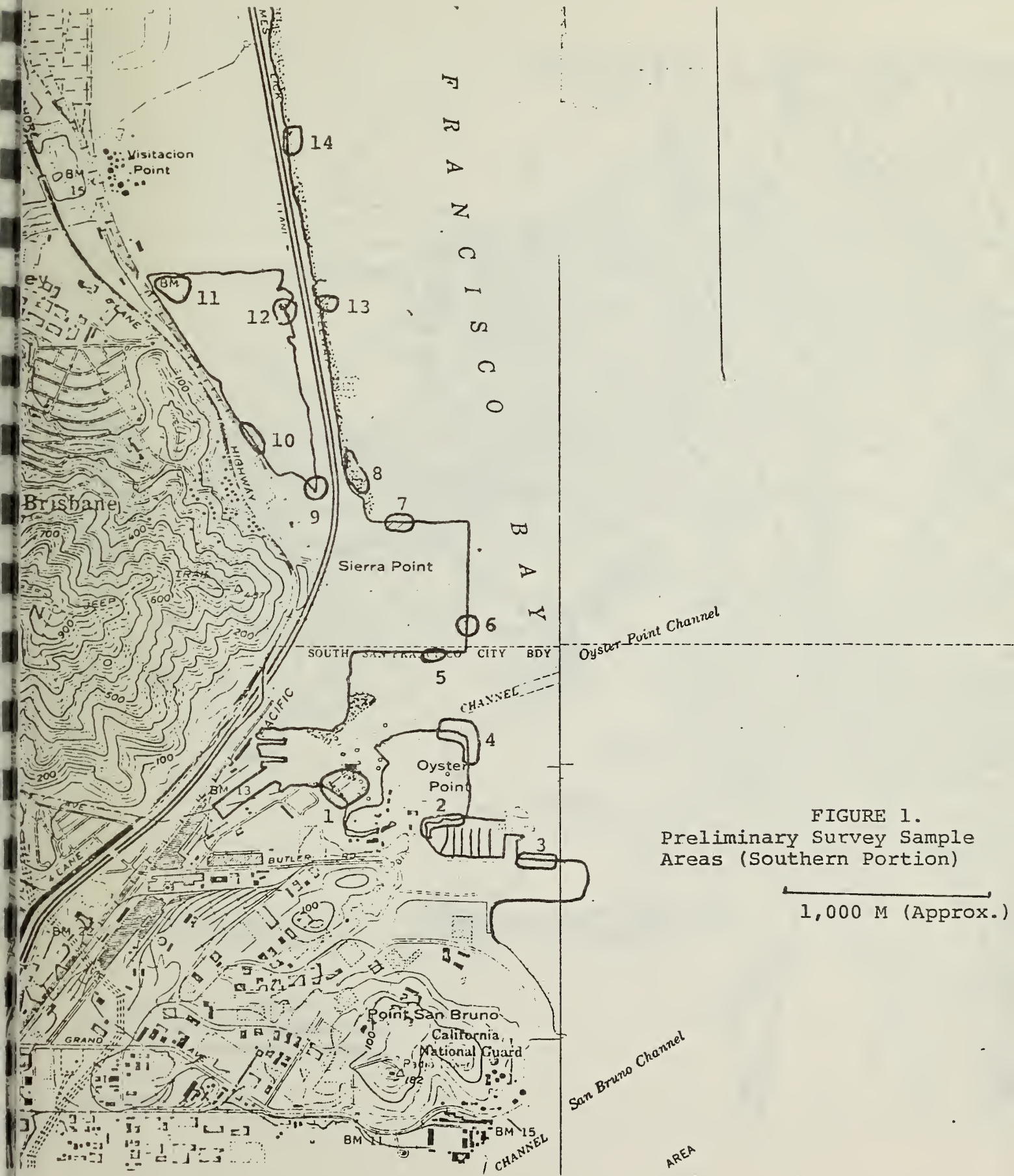

FIGURE 1.
Preliminary Survey Sample Areas (Southern Portion)

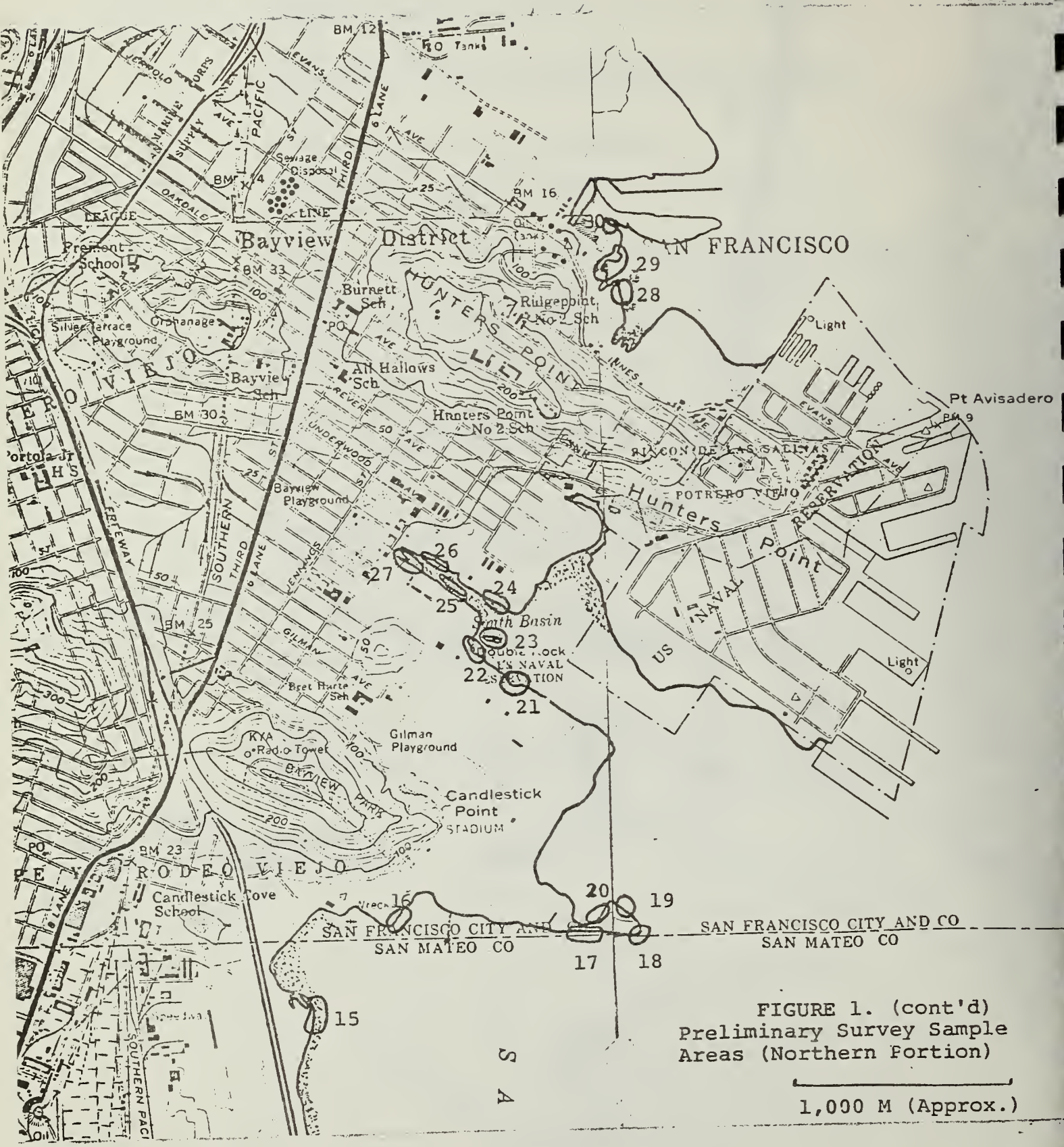

FIGURE 1. (cont'd)
Preliminary Survey Sample
Areas (Northern Portion)

1,000 M (Approx.)

APPENDIX B

SAMPLE DATA

APPENDIX B

SAMPLE DATA FOR ALL SAMPLES

A summary sheet is provided for each sample noted on the figures in the text. The area, section, and sample notation correspond to the designations in the text and the figures.

All quantitative samples are of $0.1m^2$ surface area unless otherwise noted in the station description.

Number and percent of "large" specimens ($\geq$3.8 cm shell length) are calculated for bivalve molluscs only.

"Hand dug" means the specimens were collected by hand and small rake because the substratum could not be shoveled into the screen for washing.

"Hand sorted" means that, after the sample of substratum was placed in the screen, the specimens were picked out by hand searching through the substratum, rather than by washing the entire matrix through the screen.

All polychaete fragments of one species were assumed to be portions of a single specimen.

The coding system for the samples is as follows: Individual (single) samples are coded for study area and sample number; thus, J-3 indicates the third sample from study area J (Brisbane Lagoon). Samples taken along transects are coded for study area, transect number, and sample number: thus, C-3-2 designates sample 2, from transect 3, in study area C (India Basin). Both quantitative and non-quantitative samples are so coded. Note that sample numbers do not necessarily correspond to section numbers. Please disregard the "(& REPLICATE)" notation on the data sheets; it is not relevant.

All specimens, field notes and other pertinent information relative to this study are deposited in the San Francisco Bay Project Specimen Repository, Department of Invertebrate Zoology, California Academy of Sciences, Golden Gate Park, San Francisco, California 94118.

TIME AND HEIGHT OF LOW TIDES ON COLLECTING DAYS, 1978

Low tide times and heights given below are corrected for locality (+40 minutes for Warm Water Cove and Islais Creek, based on Potrero Point correction factor; +43 minutes for the remainder, based on Point Avisadero correction factor). (All times are Pacific Standard Time.) Heights are in feet above or below mean lower low water (MLLW). Actual time of collection was not recorded for all samples; however, nearly all samples were collected within two hours before or after the time of local low tide.

Date	Time	Height	Area(s) Collected
21 June	0629	-1.7	India Basin
22 June	0717	-1.7	Yosemite Channel; South Basin
23 June	0806	-1.4	South Basin; Candlestick Point - North
18 July	0438	-1.2	Candlestick Point - South
19 July	0524	-1.4	Candlestick Point - South
20 July	0611	-1.5	Candlestick Causeway
21 July	0657	-1.3	Candlestick Causeway; Sierra Point
22 July	0957*	-1.0**	Brisbane Lagoon
03 August	0551	-0.2	Warm Water Cove
22 August	0837	+0.9	Islais Creek
17 October	1902	-0.3	South Basin
30 October	1715	+0.1	Candlestick Point - North

* Includes estimated 2¼ hour delay of time of low tide inside Brisbane Lagoon

** Refers to height in Bay; actual height in Brisbane Lagoon not known.

AREA A SECTION 1 SAMPLE (& REPLICATE) NUMBER A-1-1 SAMPLING DATE 3 Aug 1978

DESCRIPTION AND NOTES below west end of fishing pier; upper intertidal, in gravel

SPECIES		MOLLUSC SHELL LENGTH SIZE CLASSES (CM) 0.1-1.0	1.1-2.0	2.1-3.0	3.1-4.0	4.1-5.0	5.1-6.0	6.1-7.0	7.1-8.0	8.1-9.0	TOTAL #	# & % LARGE (≥3.8 CM)
Tapes japonica	#											
	%											
Mya arenaria	#											
	%											
	#											
	%											
	#											
	%											
	#											
	%											
	#											
	%											
	#											
	%											

TOTAL # SPECIES 0 TOTAL # SPECIMENS 0

AREA A SECTION 1 SAMPLE (& REPLICATE) NUMBER A-1-2 SAMPLING DATE 3 Aug 1978

DESCRIPTION AND NOTES below west end of fishing pier; mid intertidal, in mud under large concrete blocks

SPECIES		MOLLUSC SHELL LENGTH SIZE CLASSES (CM) 0.1-1.0	1.1-2.0	2.1-3.0	3.1-4.0	4.1-5.0	5.1-6.0	6.1-7.0	7.1-8.0	8.1-9.0	TOTAL #	# & % LARGE (≥3.8 CM)
Tapes japonica	#			3	3						6	3
	%			50.0	50.0							50.0
Mya arenaria	#											
	%											
Macoma nasuta	#				2*						2	2
	%				100.0							100.0
	#											
	%											
	#											
	%											
	#											
	%											
	#											
	%											

TOTAL # SPECIES 2 TOTAL # SPECIMENS 8 * 1 specimen estimate only; shell broken

AREA A SECTION 2 SAMPLE (& REPLICATE) NUMBER A-2 SAMPLING DATE 3 Aug 1978

DESCRIPTION AND NOTES approximately 30 m southeast of fishing pier; in mud under rocks and rubble; taken under piling protruding horizontally from mud; hand dug

SPECIES		MOLLUSC SHELL LENGTH SIZE CLASSES (CM) 0.1-1.0	1.1-2.0	2.1-3.0	3.1-4.0	4.1-5.0	5.1-6.0	6.1-7.0	7.1-8.0	8.1-9.0	TOTAL #	# & % LARGE (≥3.8 CM)
Tapes japonica	#		2	5	13	15					35	20
	%		5.7	14.3	37.1	42.9						57.1
Mya arenaria	#											
	%											
Macoma inquinata	#		1	1							2	0
	%		50.0	50.0								00.0
	#											
	%											
	#											
	%											
	#											
	%											
	#											
	%											
	#											
	%											

TOTAL # SPECIES 2 TOTAL # SPECIMENS 37

AREA A SECTION 3 SAMPLE (& REPLICATE) NUMBER A-3 SAMPLING DATE 3 Aug 1978

DESCRIPTION AND NOTES broad area of rocks, gravel and rubble in shallow layer over dense clay; shallow sample (approx. 4 cm) because of clay layer

SPECIES		MOLLUSC SHELL LENGTH SIZE CLASSES (CM) 0.1-1.0	1.1-2.0	2.1-3.0	3.1-4.0	4.1-5.0	5.1-6.0	6.1-7.0	7.1-8.0	8.1-9.0	TOTAL #	# & % LARGE (≥3.8 CM)
Tapes japonica	#		30	2	2	2					36	3
	%		83.3	5.6	5.6	5.6						8.3
Mya arenaria	#		1								1	0
	%		100.0									00.0
	#											
	%											
	#											
	%											
	#											
	%											
	#											
	%											
	#											
	%											
	#											
	%											

TOTAL # SPECIES 2 TOTAL # SPECIMENS 37

AREA B SECTION 1 SAMPLE (& REPLICATE) NUMBER B-1 SAMPLING DATE 22 Aug 1978

DESCRIPTION AND NOTES approx. 30 m east of Third Street bridge; mud and gravel under rocks, with dense gray clay beneath; also some empty shells

SPECIES		MOLLUSC SHELL LENGTH SIZE CLASSES (CM)									TOTAL #	# & % LARGE (≥3.8 CM
		0.1-1.0	1.1-2.0	2.1-3.0	3.1-4.0	4.1-5.0	5.1-6.0	6.1-7.0	7.1-8.0	8.1-9.0		
Tapes japonica	#		2	4							6	0
	%		33.3	66.7								00.0
Mya arenaria	#											
	%											
Macoma inquinata	#				2						2	0
	%				100.0							00.0
Macoma nasuta	#		1	1							2	0
	%		50.0	50.0								00.0
Neanthes succinea	#										1	-
	%											-
	#											
	%											
	#											
	%											
	#											
	%											

TOTAL # SPECIES 4 TOTAL # SPECIMENS 11

AREA B SECTION 2 SAMPLE (& REPLICATE) NUMBER B-2 SAMPLING DATE 22 Aug 1978

DESCRIPTION AND NOTES 5 m east of fuel dock; 2 m west of fence; mud and gravel under rocks, with dense gray clay beneath

SPECIES		MOLLUSC SHELL LENGTH SIZE CLASSES (CM)									TOTAL #	# & % LARGE (≥3.8 CM
		0.1-1.0	1.1-2.0	2.1-3.0	3.1-4.0	4.1-5.0	5.1-6.0	6.1-7.0	7.1-8.0	8.1-9.0		
Tapes japonica	#		2	6	1	2					11	2
	%		18.2	54.5	9.1	18.2						18.2
Mya arenaria	#											
	%											
Macoma inquinata	#				1	1					2	2
	%				50.0	50.0						100.0
Macoma nasuta	#			1							1	0
	%			100.0								00.0
	#											
	%											
	#											
	%											
	#											
	%											
	#											
	%											

TOTAL # SPECIES 3 TOTAL # SPECIMENS 14

AREA C SECTION 1 SAMPLE (& REPLICATE) NUMBER C-1-1 SAMPLING DATE 21 Jun 1978

DESCRIPTION AND NOTES just east of PG&E Hunters Point Power Plant outfall for Units 2 & 3; scattered large cobbles and mud; sample identified and counted, but not measured or retained

SPECIES		MOLLUSC SHELL LENGTH SIZE CLASSES (CM) 0.1-1.0	1.1-2.0	2.1-3.0	3.1-4.0	4.1-5.0	5.1-6.0	6.1-7.0	7.1-8.0	8.1-9.0	TOTAL #	# & % LARGE (≥3.8 CM)
Tapes japonica	#		ALL SMALL, BUT NOT MEASURED								39	0
	%											00.0
Mya arenaria	#											
	%											
Musculus senhousia	#		NOT MEASURED								6	0
	%											00.0
	#											
	%											
	#											
	%											
	#											
	%											
	#											
	%											
	#											
	%											

TOTAL # SPECIES 2 TOTAL # SPECIMENS 45

AREA C SECTION 1 SAMPLE (& REPLICATE) NUMBER C-1-2 SAMPLING DATE 21 Jun 1978

DESCRIPTION AND NOTES just east of PG&E Hunters Point Power Plant outfall for Units 2 & 3; black mud and empty shells

SPECIES		MOLLUSC SHELL LENGTH SIZE CLASSES (CM) 0.1-1.0	1.1-2.0	2.1-3.0	3.1-4.0	4.1-5.0	5.1-6.0	6.1-7.0	7.1-8.0	8.1-9.0	TOTAL #	# & % LARGE (≥3.8 CM)
Tapes japonica	#		3	14	10						27	0
	%		11.1	51.9	37.0							00.0
Mya arenaria	#											
	%											
	#											
	%											
	#											
	%											
	#											
	%											
	#											
	%											
	#											
	%											

TOTAL # SPECIES 1 TOTAL # SPECIMENS 27

AREA C SECTION 1 SAMPLE (& REPLICATE) NUMBER C-1-3 SAMPLING DATE 21 Jun 1978

DESCRIPTION AND NOTES just est of PG&E Hunters Point Power Plant outfall for Units 2 & 3; mud and extensive empty shells; sample identified and counted, but not measured or retained

SPECIES		MOLLUSC SHELL LENGTH SIZE CLASSES (CM)									TOTAL #	# & % LARGE (≥3.8 CM)
		0.1-1.0	1.1-2.0	2.1-3.0	3.1-4.0	4.1-5.0	5.1-6.0	6.1-7.0	7.1-8.0	8.1-9.0		
Tapes japonica	#		ALL SMALL, BUT NOT MEASURED								3	0
	%											00.0
Mya arenaria	#											
	%											
	#											
	%											
	#											
	%											
	#											
	%											
	#											
	%											
	#											
	%											
	#											
	%											

TOTAL # SPECIES 1 TOTAL # SPECIMENS 3

AREA C SECTION 2 SAMPLE (& REPLICATE) NUMBER C-2-1 SAMPLING DATE 21 Jun 1978

DESCRIPTION AND NOTES south of PG&E Hunters Point Power Plant outfall for Unit 4;cobbles over dense gray clay; sample identified and counted, but not measured or retained

SPECIES		MOLLUSC SHELL LENGTH SIZE CLASSES (CM)									TOTAL #	# & % LARGE (≥3.8 CM)
		0.1-1.0	1.1-2.0	2.1-3.0	3.1-4.0	4.1-5.0	5.1-6.0	6.1-7.0	7.1-8.0	8.1-9.0		
Tapes japonica	#		ALL SMALL, BUT NOT MEASURED								15	0
	%											00.0
Mya arenaria	#											
	%											
	#											
	%											
	#											
	%											
	#											
	%											
	#											
	%											
	#											
	%											

TOTAL # SPECIES 1 TOTAL # SPECIMENS 15

AREA C SECTION 2 SAMPLE (& REPLICATE) NUMBER C-2-2 SAMPLING DATE 21 Jun 1978

DESCRIPTION AND NOTES south of PG&E Hunters Point Power Plant outfall for Unit 4; taken at edge of mud; dense clay beneath

SPECIES		MOLLUSC SHELL LENGTH SIZE CLASSES (CM)									TOTAL #	# & % LARGE (≥3.8 CM)
		0.1-1.0	1.1-2.0	2.1-3.0	3.1-4.0	4.1-5.0	5.1-6.0	6.1-7.0	7.1-8.0	8.1-9.0		
Tapes japonica	#	8	36	5	1	4					54	5
	%	14.8	66.7	9.3	1.9	7.4						9.3
Mya arenaria	#					1					1	1
	%					100.0						100.0
Macoma balthica	#		1								1	0
	%		100.0									00.0
Macoma nasuta	#				1						1	0
	%				100.0							00.0
Neanthes succinea	#										1*	-
	%											-
	#											
	%											
	#											
	%											
	#											
	%											

TOTAL # SPECIES 5 TOTAL # SPECIMENS 58 *plus one headless fragment of same species

AREA C SECTION 2 SAMPLE (& REPLICATE) NUMBER C-2-3 SAMPLING DATE 21 Jun 1978

DESCRIPTION AND NOTES south of PG&E Hunters Point Power Plant outfall for Unit 4; soft, black mud

SPECIES		MOLLUSC SHELL LENGTH SIZE CLASSES (CM)									TOTAL #	# & % LARGE (≥3.8 CM)
		0.1-1.0	1.1-2.0	2.1-3.0	3.1-4.0	4.1-5.0	5.1-6.0	6.1-7.0	7.1-8.0	8.1-9.0		
Tapes japonica	#		1	1		3					5	3
	%		20.0	20.0		60.0						60.0
Mya arenaria	#		1								1	0
	%		100.0									00.0
Macoma balthica	#		1	1							2	0
	%		50.0	50.0								00.0
Macoma nasuta	#			4	3						7	0
	%			57.1	42.9							00.0
Nephtys caecoides	#										1	-
	%											-
Upogebia pugettensis	#										2	-
	%											-
Palaemon macrodactylus	#										4	-
	%											-
	#											
	%											

TOTAL # SPECIES 7 TOTAL # SPECIMENS 22

AREA C SECTION 4 SAMPLE (& REPLICATE) NUMBER C-3-1 SAMPLING DATE 21 Jun 1978

DESCRIPTION AND NOTES east side of small boat launch ramp area; beach front; rocks and concrete slabs over mud

SPECIES		MOLLUSC SHELL LENGTH SIZE CLASSES (CM) 0.1-1.0	1.1-2.0	2.1-3.0	3.1-4.0	4.1-5.0	5.1-6.0	6.1-7.0	7.1-8.0	8.1-9.0	TOTAL #	# & % LARGE (≥3.8 CM
Tapes japonica	#	4	3	2	3	1					13	1
	%	30.8	23.1	15.4	23.1	7.7						7.7
Mya arenaria	#											
	%											
	#											
	%											
	#											
	%											
	#											
	%											
	#											
	%											
	#											
	%											

TOTAL # SPECIES 1 TOTAL # SPECIMENS 13

AREA C SECTION 4 SAMPLE (& REPLICATE) NUMBER C-3-2 SAMPLING DATE 21 Jun 1978

DESCRIPTION AND NOTES east side of small boat launch ramp area; taken at edge of mud

SPECIES		MOLLUSC SHELL LENGTH SIZE CLASSES (CM) 0.1-1.0	1.1-2.0	2.1-3.0	3.1-4.0	4.1-5.0	5.1-6.0	6.1-7.0	7.1-8.0	8.1-9.0	TOTAL #	# & % LARGE (≥3.8 CM
Tapes japonica	#	21	48	9	11						89	2
	%	23.6	53.9	10.1	12.4							2.2
Mya arenaria	#											
	%											
Macoma nasuta	#			1							1	0
	%			100.0								00.0
Ilyanassa obsoletus	#										12	-
	%											-
	#											
	%											
	#											
	%											
	#											
	%											
	#											
	%											

TOTAL # SPECIES 3 TOTAL # SPECIMENS 102

AREA C SECTION 4 SAMPLE (& REPLICATE) NUMBER C-3-3 SAMPLING DATE 21 Jun 1978

DESCRIPTION AND NOTES east side of small boat launch ramp area; mud, scattered rocks, empty shells

SPECIES		MOLLUSC SHELL LENGTH SIZE CLASSES (CM) 0.1-1.0	1.1-2.0	2.1-3.0	3.1-4.0	4.1-5.0	5.1-6.0	6.1-7.0	7.1-8.0	8.1-9.0	TOTAL #	# & % LARGE (≥3.8 CM)
Tapes japonica	#	1	4			1					6	1
	%	16.7	66.7			16.7						16.7
Mya arenaria	#											-
	%											
Macoma balthica	#			1							1	0
	%			100.0								00.0
Macoma nasuta	#				3	2					5	3
	%				60.0	40.0						60.0
Ilyanassa obsoletus	#										2	-
	%											-
Nephtys caecoides	#										1	-
	%											-
Ascidia ceratodes	#										1	-
	%											-
	#											
	%											

TOTAL # SPECIES 6 TOTAL # SPECIMENS 16

AREA D SECTION 1 SAMPLE (& REPLICATE) NUMBER D-1-1 SAMPLING DATE 22 Jun 1978

DESCRIPTION AND NOTES western portion of channel, south of "island" (Section 5); approx. 50 m west of pipeline; approx. 15 m from south shore; thick, black clayey mud

SPECIES		MOLLUSC SHELL LENGTH SIZE CLASSES (CM) 0.1-1.0	1.1-2.0	2.1-3.0	3.1-4.0	4.1-5.0	5.1-6.0	6.1-7.0	7.1-8.0	8.1-9.0	TOTAL #	# & % LARGE (≥3.8 CM)
Tapes japonica	#											
	%											
Mya arenaria	#		16	1							17	0
	%		94.1	5.9								00.0
Macoma balthica	#		1								1	0
	%		100.0									00.0
	#											
	%											
	#											
	%											
	#											
	%											
	#											
	%											
	#											
	%											

TOTAL # SPECIES 2 TOTAL # SPECIMENS 18

AREA D SECTION 5 SAMPLE (& REPLICATE) NUMBER D-1-2 SAMPLING DATE 22 Jun 1978

DESCRIPTION AND NOTES on "island", approx. 50 m west of pipeline; mixed substratum

SPECIES		MOLLUSC SHELL LENGTH SIZE CLASSES (CM) 0.1-1.0	1.1-2.0	2.1-3.0	3.1-4.0	4.1-5.0	5.1-6.0	6.1-7.0	7.1-8.0	8.1-9.0	TOTAL #	# & % LARGE (≥3.8 CM)
Tapes japonica	#		2	3	1						6	1
	%		33.3	50.0	16.7							16.7
Mya arenaria	#	2	26			1	1				30	2
	%	6.7	86.7			3.3	3.3					6.7
Macoma balthica	#		1								1	0
	%		100.0									00.0
Neanthes sp., possible Neanthes succinea	#										1*	-
	%											-
	#											
	%											
	#											
	%											
	#											
	%											
	#											
	%											

TOTAL # SPECIES 4 TOTAL # SPECIMENS 38 *Fragment only; head missing.

AREA D SECTION 6 SAMPLE (& REPLICATE) NUMBER D-1-3 SAMPLING DATE 22 Jun 1978

DESCRIPTION AND NOTES north of "island" (Section 5); approx. 50 m west of pipeline; approx. 40 m north of south shore; black, graphite-like mud

SPECIES		MOLLUSC SHELL LENGTH SIZE CLASSES (CM) 0.1-1.0	1.1-2.0	2.1-3.0	3.1-4.0	4.1-5.0	5.1-6.0	6.1-7.0	7.1-8.0	8.1-9.0	TOTAL #	# & % LARGE (≥3.8 CM)
Tapes japonica	#											
	%											
Mya arenaria	#		41	1							42	0
	%		97.6	2.4								00.0
Macoma balthica	#		1								1	0
	%		100.0									00.0
Macoma nasuta	#		1								1	0
	%		100.0									00.0
	#											
	%											
	#											
	%											
	#											
	%											
	#											
	%											

TOTAL # SPECIES 3 TOTAL # SPECIMENS 44

AREA D SECTION 7 SAMPLE (& REPLICATE) NUMBER D-2-1 SAMPLING DATE 22 Jun 1978

DESCRIPTION AND NOTES north shore of channel; approx. 40 m west of Hunters Point Shipyard fence; midintertidal; mixed substratum of rocks, cobbles, gravel, sand and mud

SPECIES		MOLLUSC SHELL LENGTH SIZE CLASSES (CM)									TOTAL #	# & % LARGE (≥3.8 CM)
		0.1-1.0	1.1-2.0	2.1-3.0	3.1-4.0	4.1-5.0	5.1-6.0	6.1-7.0	7.1-8.0	8.1-9.0		
Tapes japonica	#		6	5	3	10					24	11
	%		25.0	20.8	12.5	41.7						45.8
Mya arenaria	#			1				1			2	1
	%			50.0				50.0				50.0
	#											
	%											
	#											
	%											
	#											
	%											
	#											
	%											
	#											
	%											
	#											
	%											

TOTAL # SPECIES 2 TOTAL # SPECIMENS 26

AREA D SECTION 7 SAMPLE (& REPLICATE) NUMBER D-2-2 SAMPLING DATE 22 Jun 1978

DESCRIPTION AND NOTES north shore of channel; approx. 40 m west of Hunters Point Shipyard fence; black, graphite-like mud; part of sample lost while washing

SPECIES		MOLLUSC SHELL LENGTH SIZE CLASSES (CM)									TOTAL #	# & % LARGE (≥3.8 CM)
		0.1-1.0	1.1-2.0	2.1-3.0	3.1-4.0	4.1-5.0	5.1-6.0	6.1-7.0	7.1-8.0	8.1-9.0		
Tapes japonica	#											
	%											
Mya arenaria	#	1	168	41							210	0
	%	0.5	80.0	19.5								00.0
Macoma balthica	#	2									2	0
	%	100.0										00.0
	#											
	%											
	#											
	%											
	#											
	%											
	#											
	%											
	#											
	%											

TOTAL # SPECIES 2 TOTAL # SPECIMENS 212

AREA D SECTION 7 SAMPLE (& REPLICATE) NUMBER D-2-3 SAMPLING DATE 22 Jun 1978

DESCRIPTION AND NOTES north shore of channel; approx. 40 m west of Hunters Point Shipyard fence; sandy mud, covered by Enteromorpha

SPECIES		MOLLUSC SHELL LENGTH SIZE CLASSES (CM) 0.1-1.0	1.1-2.0	2.1-3.0	3.1-4.0	4.1-5.0	5.1-6.0	6.1-7.0	7.1-8.0	8.1-9.0	TOTAL #	# & % LARGE (≥3.8 CM)
Tapes japonica	#											
	%											
Mya arenaria	#	3	113*	121*							237	0
	%	1.3	47.7	51.1								00.0
Macoma balthica	#	1	5								6	0
	%	16.7	83.3									00.0
	#											
	%											
	#											
	%											
	#											
	%											
	#											
	%											
	#											
	%											

TOTAL # SPECIES 2 TOTAL # SPECIMENS 243 *some shells broken, so estimate only

AREA D SECTION 3 SAMPLE (& REPLICATE) NUMBER D-3 SAMPLING DATE 22 Jun 1978

DESCRIPTION AND NOTES eastern tip of south shore of channel; mixed substratum of gravel, cobbles and mud; some seepage present

SPECIES		MOLLUSC SHELL LENGTH SIZE CLASSES (CM) 0.1-1.0	1.1-2.0	2.1-3.0	3.1-4.0	4.1-5.0	5.1-6.0	6.1-7.0	7.1-8.0	8.1-9.0	TOTAL #	# & % LARGE (≥3.8 CM
Tapes japonica	#		3	3	4	11	1				22	16
	%		13.6	13.6	18.2	50.0	4.5					72.7
Mya arenaria	#				1	3					4	4
	%				25.0	75.0						100.0
	#											
	%											
	#											
	%											
	#											
	%											
	#											
	%											
	#											
	%											

TOTAL # SPECIES 2 TOTAL # SPECIMENS 26

AREA D SECTION 4 SAMPLE (& REPLICATE) NUMBER D-4 SAMPLING DATE 22 Jun 1978

DESCRIPTION AND NOTES approx. 50 m north of Fitch Street outfall; bricks and sand over dense black clay

SPECIES		MOLLUSC SHELL LENGTH SIZE CLASSES (CM) 0.1-1.0	1.1-2.0	2.1-3.0	3.1-4.0	4.1-5.0	5.1-6.0	6.1-7.0	7.1-8.0	8.1-9.0	TOTAL #	# & % LARGE (≥3.8 CM)
Tapes japonica	#			4	1	2					7	2
	%			57.1	14.3	28.6						28.6
Mya arenaria	#											
	%											
	#											
	%											
	#											
	%											
	#											
	%											
	#											
	%											
	#											
	%											
	#											
	%											

TOTAL # SPECIES 1 TOTAL # SPECIMENS 7

AREA E SECTION 2 SAMPLE (& REPLICATE) NUMBER E-1 SAMPLING DATE 22 Jun 1978

DESCRIPTION AND NOTES north side of fill area; sandy mud beach; dense clay; sample only partially washed, and only polychaetes retained

SPECIES		MOLLUSC SHELL LENGTH SIZE CLASSES (CM) 0.1-1.0	1.1-2.0	2.1-3.0	3.1-4.0	4.1-5.0	5.1-6.0	6.1-7.0	7.1-8.0	8.1-9.0	TOTAL #	# & % LARGE (≥3.8 CM)
Tapes japonica	#											
	%											
Mya arenaria	#		ALL SMALL, BUT NOT COUNTED, MEASURED OR RETAINED								-	0
	%											00.0
Maldanidae, possible Asychis elongata	#										1*	-
	%											-
Neanthes sp., possible Neanthes succinea	#										1**	-
	%											-
	#											
	%											
	#											
	%											
	#											
	%											
	#											
	%											

TOTAL # SPECIES 3 TOTAL # SPECIMENS 2

* pygidium missing; cannot confirm

** fragments only; no head

AREA E SECTION 3 SAMPLE (& REPLICATE) NUMBER E-2 SAMPLING DATE 23 Jun 1978

DESCRIPTION AND NOTES northeast corner of fill area; rocks and gravel over sandy mud

SPECIES		MOLLUSC SHELL LENGTH SIZE CLASSES (CM) 0.1-1.0	1.1-2.0	2.1-3.0	3.1-4.0	4.1-5.0	5.1-6.0	6.1-7.0	7.1-8.0	8.1-9.0	TOTAL #	# & % LARGE (≥3.8 CM)
Tapes japonica	#				4	2					6	3
	%				66.7	33.3						50.0
Mya arenaria	#						1	1			2	2
	%						50.0	50.0				100.0
Nereis vexillosa	#										1*	-
	%											-
	#											
	%											
	#											
	%											
	#											
	%											
	#											
	%											
	#											
	%											

TOTAL # SPECIES 3 TOTAL # SPECIMENS 9 *epitokous specimen

AREA E SECTION 4 SAMPLE (& REPLICATE) NUMBER E-3 SAMPLING DATE 23 Jun 1978

DESCRIPTION AND NOTES east shore of fill area; approx. 80 m south of northeast tip; rocks, cobbles and mud

SPECIES		MOLLUSC SHELL LENGTH SIZE CLASSES (CM) 0.1-1.0	1.1-2.0	2.1-3.0	3.1-4.0	4.1-5.0	5.1-6.0	6.1-7.0	7.1-8.0	8.1-9.0	TOTAL #	# & % LARGE (≥3.8 CM)
Tapes japonica	#		1	12	16	8	2				39	12
	%		2.6	30.8	41.0	20.5	5.1					30.8
Mya arenaria	#					1					1	1
	%					100.0						100.0
	#											
	%											
	#											
	%											
	#											
	%											
	#											
	%											
	#											
	%											
	#											
	%											

TOTAL # SPECIES 2 TOTAL # SPECIMENS 40

AREA E SECTION 6 SAMPLE (& REPLICATE) NUMBER E-4 SAMPLING DATE 17 Oct 1978

DESCRIPTION AND NOTES approx. 10 m north of clay bank; mud and shells; many tubes present in mud

SPECIES		MOLLUSC SHELL LENGTH SIZE CLASSES (CM) 0.1-1.0	1.1-2.0	2.1-3.0	3.1-4.0	4.1-5.0	5.1-6.0	6.1-7.0	7.1-8.0	8.1-9.0	TOTAL #	# & % LARGE (≥3.8 CM)
Tapes japonica	#											
	%											
Mya arenaria	#		1	3							4	0
	%		25.0	75.0								00.0
Cryptomya californica	#		4	2							6	0
	%		66.7	33.3								00.0
Macoma nasuta	#			1	3						4	0
	%			25.0	75.0							00.0
	#											
	%											
	#											
	%											
	#											
	%											
	#											
	%											

TOTAL # SPECIES 3 TOTAL # SPECIMENS 14

AREA E SECTION 6 SAMPLE (& REPLICATE) NUMBER E-5 SAMPLING DATE 17 Oct 1978

DESCRIPTION AND NOTES approx. 40 m south of north end of clay bank; approx. 5 m below edge of clay bank; clay and shells; hand sorted, sample not completely washed

SPECIES		MOLLUSC SHELL LENGTH SIZE CLASSES (CM) 0.1-1.0	1.1-2.0	2.1-3.0	3.1-4.0	4.1-5.0	5.1-6.0	6.1-7.0	7.1-8.0	8.1-9.0	TOTAL #	# & % LARGE (≥3.8 CM)
Tapes japonica	#			1							1	0
	%			100.0								00.0
Mya arenaria	#		1	3							4	0
	%		25.0	75.0								00.0
Neanthes virens	#										1	-
	%											-
	#											
	%											
	#											
	%											
	#											
	%											
	#											
	%											

TOTAL # SPECIES 3 TOTAL # SPECIMENS 6

AREA E SECTION 6 SAMPLE (& REPLICATE) NUMBER E-6 SAMPLING DATE 23 Jun 1978

DESCRIPTION AND NOTES approx. 50m north of south end of clay bank; sandy mud

SPECIES		MOLLUSC SHELL LENGTH SIZE CLASSES (CM) 0.1-1.0	1.1-2.0	2.1-3.0	3.1-4.0	4.1-5.0	5.1-6.0	6.1-7.0	7.1-8.0	8.1-9.0	TOTAL #	# & % LARGE (≥3.8 CM)
Tapes japonica	#											
	%											
Mya arenaria	#			1						.	1	0
	%			100.0								00.0
Zirfaea pilsbryi	#								2		2	2
	%								100.0			100.0
	#											
	%											
	#											
	%											
	#											
	%											
	#											
	%											
	#											
	%											

TOTAL # SPECIES 2 TOTAL # SPECIMENS 3

AREA E SECTION 6 SAMPLE (& REPLICATE) NUMBER E-7 SAMPLING DATE 17 Oct 1978

DESCRIPTION AND NOTES just south of south end of clay bank; dense clay and some shells; sample hand sorted but not washed; sample not retained

SPECIES		MOLLUSC SHELL LENGTH SIZE CLASSES (CM) 0.1-1.0	1.1-2.0	2.1-3.0	3.1-4.0	4.1-5.0	5.1-6.0	6.1-7.0	7.1-8.0	8.1-9.0	TOTAL #	# & % LARGE (≥3.8 CM
Tapes japonica	#											
	%											
Mya arenaria	#											
	%											
Zirfaea pilsbryi	#		ONLY SIPHON RECOVERED: WAS LARGE ENOUGH TO BE FROM LARGE SPECIMEN; SIPHON NOT RETAINED								1	1
	%											100.0
	#											
	%											
	#											
	%											
	#											
	%											
	#											
	%											

TOTAL # SPECIES 1 TOTAL # SPECIMENS 1

AREA E SECTION 7 SAMPLE (& REPLICATE) NUMBER E-8 SAMPLING DATE 23 Jun 1978

DESCRIPTION AND NOTES bricks and rubble above sandy mud

SPECIES		MOLLUSC SHELL LENGTH SIZE CLASSES (CM) 0.1-1.0	1.1-2.0	2.1-3.0	3.1-4.0	4.1-5.0	5.1-6.0	6.1-7.0	7.1-8.0	8.1-9.0	TOTAL #	# & % LARGE (≥3.8 CM)
Tapes japonica	#	2	8	1	3						14	0
	%	14.3	57.1	7.1	21.4							00.0
Mya arenaria	#											
	%											
Paguridae, unidentified hermit crabs	#										2	-
	%											-
	#											
	%											
	#											
	%											
	#											
	%											
	#											
	%											
	#											
	%											

TOTAL # SPECIES 2 TOTAL # SPECIMENS 16

AREA F SECTION 1 SAMPLE (& REPLICATE) NUMBER F-1 SAMPLING DATE 23 Jun 1978

DESCRIPTION AND NOTES muddy sand grading into soft mud; non-quantitative sample

SPECIES		MOLLUSC SHELL LENGTH SIZE CLASSES (CM) 0.1-1.0	1.1-2.0	2.1-3.0	3.1-4.0	4.1-5.0	5.1-6.0	6.1-7.0	7.1-8.0	8.1-9.0	TOTAL #	# & % LARGE (≥3.8 CM)
Tapes japonica	#											
	%											
Mya arenaria	#			1							1	-
	%			-								-
Macoma nasuta	#			1							1	-
	%			-								-
Glycera robusta	#										1*	-
	%											-
	#											
	%											
	#											
	%											
	#											
	%											
	#											
	%											

TOTAL # SPECIES 3 TOTAL # SPECIMENS 3

* length over 30 cm, even though incomplete speci-

AREA F SECTION 3 SAMPLE (& REPLICATE) NUMBER F-2 SAMPLING DATE 23 Jun 1978

DESCRIPTION AND NOTES isthmus portion of cove; in sandy mud under embankment

SPECIES		MOLLUSC SHELL LENGTH SIZE CLASSES (CM) 0.1-1.0	1.1-2.0	2.1-3.0	3.1-4.0	4.1-5.0	5.1-6.0	6.1-7.0	7.1-8.0	8.1-9.0	TOTAL #	# & % LARGE (≥3.8 CM)
Tapes japonica	#	1	7								8	0
	%	12.5	87.5									00.0
Mya arenaria	#		12								12	0
	%		100.0									00.0
Cryptomya californica	#	5	9	11							25	0
	%	20.0	36.0	44.0								00.0
	#											
	%											
	#											
	%											
	#											
	%											
	#											
	%											
	#											
	%											

TOTAL # SPECIES 3 TOTAL # SPECIMENS 45

AREA F SECTION 4 SAMPLE (& REPLICATE) NUMBER F-3 SAMPLING DATE 23 Jun 1978

DESCRIPTION AND NOTES east side of small cove; sandy mud grading into soft mud

SPECIES		MOLLUSC SHELL LENGTH SIZE CLASSES (CM) 0.1-1.0	1.1-2.0	2.1-3.0	3.1-4.0	4.1-5.0	5.1-6.0	6.1-7.0	7.1-8.0	8.1-9.0	TOTAL #	# & % LARGE (≥3.8 CM)
Tapes japonica	#	1	19	1					-		21	0
	%	4.8	90.5	4.8								00.0
Mya arenaria	#	4	257	73							334	0
	%	1.2	76.9	21.9								00.0
Cryptomya californica	#		1								1	0
	%		100.0									00.0
Musculus senhousia	#		3								3	0
	%		100.0									00.0
	#											
	%											
	#											
	%											
	#											
	%											
	#											
	%											

TOTAL # SPECIES 4 TOTAL # SPECIMENS 359

AREA F SECTION 5 SAMPLE (& REPLICATE) NUMBER F-4 SAMPLING DATE 30 Oct 1978

DESCRIPTION AND NOTES west end of Section 5; mud and shells; tubes present in mud

SPECIES		MOLLUSC SHELL LENGTH SIZE CLASSES (CM) 0.1-1.0	1.1-2.0	2.1-3.0	3.1-4.0	4.1-5.0	5.1-6.0	6.1-7.0	7.1-8.0	8.1-9.0	TOTAL #	# & % LARGE (≥3.8 CM)
Tapes japonica	#	1		1	1						3	0
	%	33.3		33.3	33.3							00.0
Mya arenaria	#		9	21	4						34	0
	%		26.5	61.8	11.8							00.0
	#											
	%											
	#											
	%											
	#											
	%											
	#											
	%											
	#											
	%											

TOTAL # SPECIES 2 TOTAL # SPECIMENS 37

AREA F SECTION 5 SAMPLE (& REPLICATE) NUMBER F-5 SAMPLING DATE 23 Jun 1978

DESCRIPTION AND NOTES middle of Section 5; clay

SPECIES		MOLLUSC SHELL LENGTH SIZE CLASSES (CM) 0.1-1.0	1.1-2.0	2.1-3.0	3.1-4.0	4.1-5.0	5.1-6.0	6.1-7.0	7.1-8.0	8.1-9.0	TOTAL #	# & % LARGE (≥3.8 CM)
Tapes japonica	#											
	%											
Mya arenaria	#											
	%											
Zirfaea pilsbryi	#			1				1			2	1
	%			50.0				50.0				50.0
	#											
	%											
	#											
	%											
	#											
	%											
	#											
	%											

TOTAL # SPECIES 1 TOTAL # SPECIMENS 2

AREA F SECTION 5 SAMPLE (& REPLICATE) NUMBER F-6 SAMPLING DATE 30 Oct 1978

DESCRIPTION AND NOTES east end of Section 5, adjacent to rock beach front of Section 6 (at tip of point); dense clay and shells

SPECIES		MOLLUSC SHELL LENGTH SIZE CLASSES (CM) 0.1-1.0	1.1-2.0	2.1-3.0	3.1-4.0	4.1-5.0	5.1-6.0	6.1-7.0	7.1-8.0	8.1-9.0	TOTAL #	# & % LARGE (≥3.8 CM)
Tapes japonica	#											
	%											
Mya arenaria	#			1							1	0
	%			100.0								00.0
Zirfaea pilsbryi	#						1				1	1
	%						100.0					100.0
	#											
	%											
	#											
	%											
	#											
	%											
	#											
	%											

TOTAL # SPECIES 2 TOTAL # SPECIMENS 2

AREA F SECTION 6 SAMPLE (& REPLICATE) NUMBER F-7 SAMPLING DATE 23 Jun 1978

DESCRIPTION AND NOTES very tip of Point; midintertidal; rocks and mud; seepage across beach front

SPECIES		MOLLUSC SHELL LENGTH SIZE CLASSES (CM) 0.1-1.0	1.1-2.0	2.1-3.0	3.1-4.0	4.1-5.0	5.1-6.0	6.1-7.0	7.1-8.0	8.1-9.0	TOTAL #	# & % LARGE (≥3.8 CM)
Tapes japonica	#					1					1	1
	%					100.0						100.0
Mya arenaria	#	1	3								4	0
	%	25.0	75.0									00.0
Neanthes succinea	#										1*	-
	%											-
	#											
	%											
	#											
	%											
	#											
	%											
	#											
	%											

TOTAL # SPECIES 3 TOTAL # SPECIMENS 6

*plus two headless fragments of same species

AREA G SECTION 1 SAMPLE (& REPLICATE) NUMBER G-1-1 SAMPLING DATE 18 Jul 1978

DESCRIPTION AND NOTES approx. 50 m west of tip of point; sand and cobbles, covered with Ulva; sample counted and identified, but not measured or retained

SPECIES		MOLLUSC SHELL LENGTH SIZE CLASSES (CM) 0.1-1.0	1.1-2.0	2.1-3.0	3.1-4.0	4.1-5.0	5.1-6.0	6.1-7.0	7.1-8.0	8.1-9.0	TOTAL #	# & % LARGE (≥3.8 CM)
Tapes japonica	#		SMALL, BUT NOT MEASURED								1	0
	%											00.0
Mya arenaria	#		SMALL, BUT NOT MEASURED								1	0
	%											00.0
	#											
	%											
	#											
	%											
	#											
	%											
	#											
	%											
	#											
	%											

TOTAL # SPECIES 2 TOTAL # SPECIMENS 2

AREA G SECTION 1 SAMPLE (& REPLICATE) NUMBER G-1-2 SAMPLING DATE 18 Jul 1978

DESCRIPTION AND NOTES approx. 50 m west of tip of point; sand and cobbles, covered by Ulva

SPECIES		MOLLUSC SHELL LENGTH SIZE CLASSES (CM) 0.1-1.0	1.1-2.0	2.1-3.0	3.1-4.0	4.1-5.0	5.1-6.0	6.1-7.0	7.1-8.0	8.1-9.0	TOTAL #	# & % LARGE (≥3.8 CM)
Tapes japonica	#			3	4	4	3	1			15	9
	%			20.0	26.7	26.7	20.0	6.7				60.0
Mya arenaria	#		1			1*	1*				3	2
	%		33.3			33.3	33.3					66.7
Musculus senhousia	#		1								1	0
	%		100.0									00.0
Neanthes succinea	#										1**	-
	%											-
	#											
	%											
	#											
	%											
	#											
	%											

TOTAL # SPECIES 4 TOTAL # SPECIMENS 20

* approximate length; shell broken

** plus three headless fragments of same species

AREA G SECTION 1 SAMPLE (& REPLICATE) NUMBER G-1-3 SAMPLING DATE 18 Jul 1978

DESCRIPTION AND NOTES approx. 50 m west of tip of point; mud substratum

SPECIES		MOLLUSC SHELL LENGTH SIZE CLASSES (CM)									TOTAL #	# & % LARGE (≥3.8 CM)
		0.1-1.0	1.1-2.0	2.1-3.0	3.1-4.0	4.1-5.0	5.1-6.0	6.1-7.0	7.1-8.0	8.1-9.0		
Tapes japonica	#											
	%											
Mya arenaria	#		24	4							28	0
	%		85.7	14.3								00.0
Musculus senhousia	#		1									0
	%		100.0									00.0
	#											
	%											
	#											
	%											
	#											
	%											
	#											
	%											
	#											
	%											

TOTAL # SPECIES 2 TOTAL # SPECIMENS 29

AREA G SECTION 1 SAMPLE (& REPLICATE) NUMBER G-2 SAMPLING DATE 18 Jul 1978

DESCRIPTION AND NOTES on isthmus portion of point, opposite east shore of small cove; just east of wrecked vehicle; sand and gravel over clay

SPECIES		MOLLUSC SHELL LENGTH SIZE CLASSES (CM)									TOTAL #	# & % LARGE (≥3.8 CM
		0.1-1.0	1.1-2.0	2.1-3.0	3.1-4.0	4.1-5.0	5.1-6.0	6.1-7.0	7.1-8.0	8.1-9.0		
Tapes japonica	#			2	3	3	1				9	5
	%			22.2	33.3	33.3	11.1					55.6
Mya arenaria	#		4								4	0
	%		100.0									00.0
	#											
	%											
	#											
	%											
	#											
	%											
	#											
	%											
	#											
	%											

TOTAL # SPECIES 2 TOTAL # SPECIMENS 13

AREA G SECTION 1 SAMPLE (& REPLICATE) NUMBER G-3-1 SAMPLING DATE 18 Jul 1978

DESCRIPTION AND NOTES approx. 70 m east of old building; sand and gravel, at upper end of portion of beach front covered by Ulva

SPECIES		MOLLUSC SHELL LENGTH SIZE CLASSES (CM) 0.1-1.0	1.1-2.0	2.1-3.0	3.1-4.0	4.1-5.0	5.1-6.0	6.1-7.0	7.1-8.0	8.1-9.0	TOTAL #	# & % LARGE (≥3.8 CM)
Tapes japonica	#		1	2	1	2	1				7	4
	%		14.3	28.6	14.3	28.6	14.3					57.1
Mya arenaria	#											
	%											
	#											
	%											
	#											
	%											
	#											
	%											
	#											
	%											
	#											
	%											
	#											
	%											

TOTAL # SPECIES 1 TOTAL # SPECIMENS 7

AREA G SECTION 1 SAMPLE (& REPLICATE) NUMBER G-3-2 SAMPLING DATE 18 Jul 1978

DESCRIPTION AND NOTES approx. 70 m east of old building; sand and gravel, at lower end of portion of beach front covered by Ulva

SPECIES		MOLLUSC SHELL LENGTH SIZE CLASSES (CM) 0.1-1.0	1.1-2.0	2.1-3.0	3.1-4.0	4.1-5.0	5.1-6.0	6.1-7.0	7.1-8.0	8.1-9.0	TOTAL #	# & % LARGE (≥3.8 CM)
Tapes japonica	#		4	13	7	4					28	8
	%		14.3	46.4	25.0	14.3						28.6
Mya arenaria	#											
	%											
Neanthes virens	#										2*	-
	%											-
	#											
	%											
	#											
	%											
	#											
	%											
	#											
	%											

TOTAL # SPECIES 2 TOTAL # SPECIMENS 30 * plus six headless fragments of same species

AREA G SECTION 4 SAMPLE (& REPLICATE) NUMBER G-4 SAMPLING DATE 18 Jul 1978

DESCRIPTION AND NOTES directly south of old building, on small point of land; large and small cobbles, and sand in shallow layer over dense clay; some Ulva present; sample not retained

SPECIES		MOLLUSC SHELL LENGTH SIZE CLASSES (CM)									TOTAL #	# & % LARGE (≥3.8 CM)
		0.1-1.0	1.1-2.0	2.1-3.0	3.1-4.0	4.1-5.0	5.1-6.0	6.1-7.0	7.1-8.0	8.1-9.0		
Tapes japonica	#											
	%											
Mya arenaria	#		SMALL, BUT NOT MEASURED								1	0
	%											00.0
	#											
	%											
	#											
	%											
	#											
	%											
	#											
	%											
	#											
	%											

TOTAL # SPECIES 1 TOTAL # SPECIMENS 1

AREA G SECTION 4 SAMPLE (& REPLICATE) NUMBER G-5 SAMPLING DATE 19 Jul 1978

DESCRIPTION AND NOTES at tip of larger (eastern) of two promontories; cobbles, rubble, gravel, etc.

SPECIES		MOLLUSC SHELL LENGTH SIZE CLASSES (CM)									TOTAL #	# & % LARGE (≥3.8 CM)
		0.1-1.0	1.1-2.0	2.1-3.0	3.1-4.0	4.1-5.0	5.1-6.0	6.1-7.0	7.1-8.0	8.1-9.0		
Tapes japonica	#		5	13	5	8					31	10
	%		16.1	41.9	16.1	25.8						32.3
Mya arenaria	#											
	%											
	#											
	%											
	#											
	%											
	#											
	%											
	#											
	%											
	#											
	%											

TOTAL # SPECIES 1 TOTAL # SPECIMENS 31

AREA G SECTION 4 SAMPLE (& REPLICATE) NUMBER G-6 SAMPLING DATE 19 Jul 1978

DESCRIPTION AND NOTES approx. 30 m east of small sand beach between two promontories; taken in gravel at edge of mud

SPECIES		MOLLUSC SHELL LENGTH SIZE CLASSES (CM) 0.1-1.0	1.1-2.0	2.1-3.0	3.1-4.0	4.1-5.0	5.1-6.0	6.1-7.0	7.1-8.0	8.1-9.0	TOTAL #	# & % LARGE (≥3.8 CM)
Tapes japonica	#		3	8	7	5					23	8
	%		13.0	34.8	30.4	21.7						34.8
Mya arenaria	#		22	3							25	0
	%		88.0	12.0								00.0
Cryptomya californica	#		1								1	0
	%		100.0									00.0
	#											
	%											
	#											
	%											
	#											
	%											
	#											
	%											
	#											
	%											

TOTAL # SPECIES 3 TOTAL # SPECIMENS 49

AREA G SECTION 6 SAMPLE (& REPLICATE) NUMBER G-7 SAMPLING DATE 19 Jul 1978

DESCRIPTION AND NOTES approx. 20 m south of double row of low pilings in mud; rocks and sand

SPECIES		MOLLUSC SHELL LENGTH SIZE CLASSES (CM) 0.1-1.0	1.1-2.0	2.1-3.0	3.1-4.0	4.1-5.0	5.1-6.0	6.1-7.0	7.1-8.0	8.1-9.0	TOTAL #	# & % LARGE (≥3.8 CM)
Tapes japonica	#	2	9	5	12	2	1				31	3
	%	6.5	29.0	16.1	38.7	6.5	3.2					9.7
Mya arenaria	#		2		2						4	1
	%		50.0		50.0							25.0
Macoma balthica	#		3								3	0
	%		100.0									00.0
	#											
	%											
	#											
	%											
	#											
	%											
	#											
	%											
	#											
	%											

TOTAL # SPECIES 3 TOTAL # SPECIMENS 38

AREA H SECTION 1 SAMPLE (& REPLICATE) NUMBER H-1-1 SAMPLING DATE 20 Jul 1978

DESCRIPTION AND NOTES east side of freeway offramp peninsula; upper intertidal; silt and cobbles over broken shells

SPECIES		MOLLUSC SHELL LENGTH SIZE CLASSES (CM) 0.1-1.0	1.1-2.0	2.1-3.0	3.1-4.0	4.1-5.0	5.1-6.0	6.1-7.0	7.1-8.0	8.1-9.0	TOTAL #	# & % LARGE (≥3.8 CM)
Tapes japonica	#											
	%											
Mya arenaria	#											
	%											
	#											
	%											
	#											
	%											
	#											
	%											
	#											
	%											
	#											
	%											

TOTAL # SPECIES 0 TOTAL # SPECIMENS 0

AREA H SECTION 1 SAMPLE (& REPLICATE) NUMBER H-1-2 SAMPLING DATE 20 Jul 1978

DESCRIPTION AND NOTES east side of freeway offramp peninsula; midintertidal; silt and cobbles over brown clay; sample not measured or retained

SPECIES		MOLLUSC SHELL LENGTH SIZE CLASSES (CM) 0.1-1.0	1.1-2.0	2.1-3.0	3.1-4.0	4.1-5.0	5.1-6.0	6.1-7.0	7.1-8.0	8.1-9.0	TOTAL #	# & % LARGE (≥3.8 CM)
Tapes japonica	#		ALL	SMALL,	BUT NOT	MEASURED					5	0
	%											00.0
Mya arenaria	#											
	%											
	#											
	%											
	#											
	%											
	#											
	%											
	#											
	%											
	#											
	%											

TOTAL # SPECIES 1 TOTAL # SPECIMENS 5

AREA H SECTION 2 SAMPLE (& REPLICATE) NUMBER H-2 SAMPLING DATE 20 Jul 1978

DESCRIPTION AND NOTES approx. 30 m north of sign structure at beginning of offramp; concrete blocks on shells and mud, all on dense gray clay; Ulva and Enteromorpha present

SPECIES		MOLLUSC SHELL LENGTH SIZE CLASSES (CM) 0.1-1.0	1.1-2.0	2.1-3.0	3.1-4.0	4.1-5.0	5.1-6.0	6.1-7.0	7.1-8.0	8.1-9.0	TOTAL #	# & % LARGE (≥3.8 CM)
Tapes japonica	#	1	31	16	12						60	1
	%	1.7	51.7	26.7	20.0							1.7
Mya arenaria	#		13								13	0
	%		100.0									00.0
Musculus senhousia	#		1								1	0
	%		100.0									00.0
	#											
	%											
	#											
	%											
	#											
	%											
	#											
	%											
	#											
	%											

TOTAL # SPECIES 3 TOTAL # SPECIMENS 74

AREA H SECTION 4 SAMPLE (& REPLICATE) NUMBER H-3 SAMPLING DATE 20 Jul 1978

DESCRIPTION AND NOTES approx. 30 m south of drain culvert under freeway; taken just above edge of mud; substratum of cobbles, shells and mud

SPECIES		MOLLUSC SHELL LENGTH SIZE CLASSES (CM) 0.1-1.0	1.1-2.0	2.1-3.0	3.1-4.0	4.1-5.0	5.1-6.0	6.1-7.0	7.1-8.0	8.1-9.0	TOTAL #	# & % LARGE (≥3.8 CM)
Tapes japonica	#			4	12	6					22	12
	%			18.2	54.5	27.3						54.5
Mya arenaria	#								1	1	2	2
	%								50.0	50.0		100.0
	#											
	%											
	#											
	%											
	#											
	%											
	#											
	%											
	#											
	%											

TOTAL # SPECIES 2 TOTAL # SPECIMENS 24

AREA H SECTION 4 SAMPLE (& REPLICATE) NUMBER H-4 SAMPLING DATE 20 Jul 1978

DESCRIPTION AND NOTES small offshore rockpile, approx. 100 m north of stakes driven into the mud flat; sample hand dug

SPECIES		MOLLUSC SHELL LENGTH SIZE CLASSES (CM) 0.1-1.0	1.1-2.0	2.1-3.0	3.1-4.0	4.1-5.0	5.1-6.0	6.1-7.0	7.1-8.0	8.1-9.0	TOTAL #	# & % LARGE (≥3.8 CM)
Tapes japonica	#		3	5	3	5					16	5
	%		18.8	31.2	18.8	31.2						31.2
Mya arenaria	#											
	%											
	#											
	%											
	#											
	%											
	#											
	%											
	#											
	%											
	#											
	%											

TOTAL # SPECIES 1 TOTAL # SPECIMENS 16

AREA H SECTION 4 SAMPLE (& REPLICATE) NUMBER H-5 SAMPLING DATE 20 Jul 1978

DESCRIPTION AND NOTES approx. 30 m south of drain culvert and large pipe (abandoned outfall?) under freeway; shells and mud under large rock, all on clay; hand dug; surface area approx. 0.125 m^2

SPECIES		MOLLUSC SHELL LENGTH SIZE CLASSES (CM) 0.1-1.0	1.1-2.0	2.1-3.0	3.1-4.0	4.1-5.0	5.1-6.0	6.1-7.0	7.1-8.0	8.1-9.0	TOTAL #	# & % LARGE (≥3.8 CM)
Tapes japonica	#		4	2	7	8	4				25	16
	%		16.0	8.0	28.0	32.0	16.0					64.0
Mya arenaria	#											
	%											
	#											
	%											
	#											
	%											
	#											
	%											
	#											
	%											
	#											
	%											

TOTAL # SPECIES 1 TOTAL # SPECIMENS 25

AREA H SECTION 6 SAMPLE (& REPLICATE) NUMBER H-6 SAMPLING DATE 21 Jul 1978

DESCRIPTION AND NOTES approx. 20 m south of Brisbane Lagoon culverts; approx. 1 m above edge of mud; rocks over dense gray clay

SPECIES		MOLLUSC SHELL LENGTH SIZE CLASSES (CM) 0.1-1.0	1.1-2.0	2.1-3.0	3.1-4.0	4.1-5.0	5.1-6.0	6.1-7.0	7.1-8.0	8.1-9.0	TOTAL #	# & % LARGE (≥3.8 CM)
Tapes japonica	#			1	3	2	1				7	4
	%			14.3	42.9	28.6	14.3					57.1
Mya arenaria	#		13	2							15	0
	%		86.7	13.3								00.0
	#											
	%											
	#											
	%											
	#											
	%											
	#											
	%											
	#											
	%											
	#											
	%											

TOTAL # SPECIES 2 TOTAL # SPECIMENS 22

AREA H SECTION 6 SAMPLE (& REPLICATE) NUMBER H-7 SAMPLING DATE 21 Jul 1978

DESCRIPTION AND NOTES approx. 100 m south of Brisbane Lagoon culverts; taken at edge of mud; non-quantitative sample

SPECIES		MOLLUSC SHELL LENGTH SIZE CLASSES (CM) 0.1-1.0	1.1-2.0	2.1-3.0	3.1-4.0	4.1-5.0	5.1-6.0	6.1-7.0	7.1-8.0	8.1-9.0	TOTAL #	# & % LARGE (≥3.8 CM)
Tapes japonica	#		2	3							5	0
	%		-	-								-
Mya arenaria	#											
	%											
	#											
	%											
	#											
	%											
	#											
	%											
	#											
	%											
	#											
	%											

TOTAL # SPECIES 1 TOTAL # SPECIMENS 5

AREA H SECTION 6 SAMPLE (& REPLICATE) NUMBER H-8 SAMPLING DATE 21 Jul 1978

DESCRIPTION AND NOTES rockpile approx. 320 m south of Brisbane Lagoon culverts; rocks over mud and shells, all on dense clay

SPECIES		MOLLUSC SHELL LENGTH SIZE CLASSES (CM)									TOTAL #	# & % LARGE (≥3.8 CM)
		0.1-1.0	1.1-2.0	2.1-3.0	3.1-4.0	4.1-5.0	5.1-6.0	6.1-7.0	7.1-8.0	8.1-9.0		
Tapes japonica	#		1	10	7	5	1				24	8
	%		4.2	41.7	29.2	20.8	4.2					33.3
Mya arenaria	#											
	%											
	#											
	%											
	#											
	%											
	#											
	%											
	#											
	%											
	#											
	%											
	#											
	%											

TOTAL # SPECIES 1 TOTAL # SPECIMENS 24

AREA H SECTION 6 SAMPLE (& REPLICATE) NUMBER H-9 SAMPLING DATE 21 Jul 1978

DESCRIPTION AND NOTES approx. 120 m north of south end of causeway; approx. 1.5 m above edge of mud; rock and mud substratum

SPECIES		MOLLUSC SHELL LENGTH SIZE CLASSES (CM)									TOTAL #	# & % LARGE (≥3.8 CM)
		0.1-1.0	1.1-2.0	2.1-3.0	3.1-4.0	4.1-5.0	5.1-6.0	6.1-7.0	7.1-8.0	8.1-9.0		
Tapes japonica	#	1	3	4	12	3	2				25	8
	%	4.0	12.0	16.0	48.0	12.0	8.0					32.0
Mya arenaria	#			1							1	0
	%			100.0								00.0
	#											
	%											
	#											
	%											
	#											
	%											
	#											
	%											
	#											
	%											

TOTAL # SPECIES 2 TOTAL # SPECIMENS 26

AREA H SECTION 6 SAMPLE (& REPLICATE) NUMBER H-10 SAMPLING DATE 21 Jul 1978

DESCRIPTION AND NOTES approx. 30 m north of south end of causeway; rocks on clay; hand dug

SPECIES		MOLLUSC SHELL LENGTH SIZE CLASSES (CM) 0.1-1.0	1.1-2.0	2.1-3.0	3.1-4.0	4.1-5.0	5.1-6.0	6.1-7.0	7.1-8.0	8.1-9.0	TOTAL #	# & % LARGE (≥3.8 CM)
Tapes japonica	#		3	10	27	9	2				51	11
	%		5.9	19.6	52.9	17.6	3.9					21.6
Mya arenaria	#							2			2	.2
	%							100.0				100.0
	#											
	%											
	#											
	%											
	#											
	%											
	#											
	%											
	#											
	%											

TOTAL # SPECIES 2 TOTAL # SPECIMENS 53

AREA I SECTION 1 SAMPLE (& REPLICATE) NUMBER I-1-1 SAMPLING DATE 21 Jul 1978

DESCRIPTION AND NOTES approx. 330 m east of junction of fill with Candlestick Causeway; approx. 1.5 m above edge of mud; rocks, gravel and mud over clay

SPECIES		MOLLUSC SHELL LENGTH SIZE CLASSES (CM) 0.1-1.0	1.1-2.0	2.1-3.0	3.1-4.0	4.1-5.0	5.1-6.0	6.1-7.0	7.1-8.0	8.1-9.0	TOTAL #	# & % LARGE (≥3.8 CM)
Tapes japonica	#		4	13							17	0
	%		23.5	76.5								00.0
Mya arenaria	#		2								?	0
	%		100.0									00.0
Neanthes virens	#										1	-
	%											-
	#											
	%											
	#											
	%											
	#											
	%											
	#											
	%											
	#											
	%											

TOTAL # SPECIES 3 TOTAL # SPECIMENS 20

AREA I SECTION 1 SAMPLE (& REPLICATE) NUMBER I-1-2 SAMPLING DATE 21 Jul 1978

DESCRIPTION AND NOTES approx. 330 m east of junction of fill with Candlestick Causeway; sample taken at edge of mud; shallow layer of mud over clay

SPECIES		MOLLUSC SHELL LENGTH SIZE CLASSES (CM) 0.1-1.0	1.1-2.0	2.1-3.0	3.1-4.0	4.1-5.0	5.1-6.0	6.1-7.0	7.1-8.0	8.1-9.0	TOTAL #	# & % LARGE (≥3.8 CM
Tapes japonica	#		11	6							17	0
	%		64.7	35.3								00.0
Mya arenaria	#	1	87	2							90	0
	%	1.1	96.7	2.2								00.0
Mytilus edulis	#		1								1	0
	%		100.0									00.0
	#											
	%											
	#											
	%											
	#											
	%											
	#											
	%											
	#											
	%											

TOTAL # SPECIES 3 TOTAL # SPECIMENS 108

AREA I SECTION 2 SAMPLE (& REPLICATE) NUMBER I-2 SAMPLING DATE 21 Jul 1978

DESCRIPTION AND NOTES approx. 200 m south of northeast corner of fill area; approx. 1 m above edge of mud; mixed substratum of rocks, gravel, sand, broken shells and mud

SPECIES		MOLLUSC SHELL LENGTH SIZE CLASSES (CM) 0.1-1.0	1.1-2.0	2.1-3.0	3.1-4.0	4.1-5.0	5.1-6.0	6.1-7.0	7.1-8.0	8.1-9.0	TOTAL #	# & % LARGE (≥3.8 CM
Tapes japonica	#			5	2	6					13	6
	%			38.5	15.4	46.2						46.2
Mya arenaria	#		2								2	0
	%		100.0									00.0
Neanthes succinea	#										1*	-
	%											-
	#											
	%											
	#											
	%											
	#											
	%											
	#											
	%											
	#											
	%											

TOTAL # SPECIES 3 TOTAL # SPECIMENS 16 * plus one headless fragment of same species

AREA I SECTION 2 SAMPLE (& REPLICATE) NUMBER I-3 SAMPLING DATE 21 Jul 1978

DESCRIPTION AND NOTES approx. 300 m south of northeat corner of fill area; approx. 0.5 m above edge of mud; hand dug

SPECIES		MOLLUSC SHELL LENGTH SIZE CLASSES (CM) 0.1-1.0	1.1-2.0	2.1-3.0	3.1-4.0	4.1-5.0	5.1-6.0	6.1-7.0	7.1-8.0	8.1-9.0	TOTAL #	# & % LARGE (≥3.8 CM)
Tapes japonica	#			2		8	2	1			13	11
	%			15.4		61.5	15.4	7.7				84.6
Mya arenaria	#											
	%											
	#											
	%											
	#											
	%											
	#											
	%											
	#											
	%											
	#											
	%											

TOTAL # SPECIES 1 TOTAL # SPECIMENS 13

AREA I SECTION 3 SAMPLE (& REPLICATE) NUMBER I-4 SAMPLING DATE 21 Jul 1978

DESCRIPTION AND NOTES approx. 40 m west of southeast corner of fill area; taken at upper edge of zone of beach front covered by Ulva; rocks and gravel over mud; surface area approx. 0.125 m^2

SPECIES		MOLLUSC SHELL LENGTH SIZE CLASSES (CM) 0.1-1.0	1.1-2.0	2.1-3.0	3.1-4.0	4.1-5.0	5.1-6.0	6.1-7.0	7.1-8.0	8.1-9.0	TOTAL #	# & % LARGE (≥3.8 CM)
Tapes japonica	#		1	4	4	9	1				19	11
	%		5.3	21.1	21.1	47.4	5.3					57.9
Mya arenaria	#											
	%											
Ostrea lurida	#			1							1	0
	%			100.0								00.0
	#											
	%											
	#											
	%											
	#											
	%											
	#											
	%											

TOTAL # SPECIES 2 TOTAL # SPECIMENS 20

AREA J SECTION 1 SAMPLE (& REPLICATE) NUMBER J-1 SAMPLING DATE 22 Jul 1978

DESCRIPTION AND NOTES approx. 25 m south of culverts; cobbles and mud

SPECIES		MOLLUSC SHELL LENGTH SIZE CLASSES (CM) 0.1-1.0	1.1-2.0	2.1-3.0	3.1-4.0	4.1-5.0	5.1-6.0	6.1-7.0	7.1-8.0	8.1-9.0	TOTAL #	# & % LARGE (≥3.8 CM
Tapes japonica	#		6	2	3						11	0
	%		54.5	18.2	27.3							00.0
Mya arenaria	#		68			1	2*	2	1	1	75	7
	%		90.7			1.3	2.7	2.7	1.3	1.3		9.3
	#											
	%											
	#											
	%											
	#											
	%											
	#											
	%											
	#											
	%											

TOTAL # SPECIES 2 TOTAL # SPECIMENS 86 * 1 specimen estimate only; shell broken

AREA J SECTION 1 SAMPLE (& REPLICATE) NUMBER J-2 SAMPLING DATE 22 Jul 1978

DESCRIPTION AND NOTES approx. 240 m south of culverts; approx. 10 m south of large shell windrow; rocks and cobbles over gray mud; hand dug

SPECIES		MOLLUSC SHELL LENGTH SIZE CLASSES (CM) 0.1-1.0	1.1-2.0	2.1-3.0	3.1-4.0	4.1-5.0	5.1-6.0	6.1-7.0	7.1-8.0	8.1-9.0	TOTAL #	# & % LARGE (≥3.8 CM
Tapes japonica	#				5	6					11	8
	%				45.5	54.5						72.7
Mya arenaria	#					2	2	1	1		6	6
	%					33.3	33.3	16.7	16.7			100.0
Mytilus edulis	#					1					1	1
	%					100.0						100.0
	#											
	%											
	#											
	%											
	#											
	%											
	#											
	%											

TOTAL # SPECIES 3 TOTAL # SPECIMENS 18

AREA J SECTION 1 SAMPLE (& REPLICATE) NUMBER J-3 SAMPLING DATE 22 Jul 1978

DESCRIPTION AND NOTES approx. 540 m south of culverts, in rockpile; rocks on dense gray clay; surface area approx. 0.2 m^2; hand dug

SPECIES		MOLLUSC SHELL LENGTH SIZE CLASSES (CM) 0.1-1.0	1.1-2.0	2.1-3.0	3.1-4.0	4.1-5.0	5.1-6.0	6.1-7.0	7.1-8.0	8.1-9.0	TOTAL #	# & % LARGE (≥3.8 CM)
Tapes japonica	#			13	3	5	5				26	10
	%			50.0	11.5	19.2	19.2					38.5
Mya arenaria	#						1	1	1		3	3
	%						33.3	33.3	33.3			100.0
Cirriformia spirabrancha	#										1	-
	%											-
	#											
	%											
	#											
	%											
	#											
	%											
	#											
	%											
	#											
	%											

TOTAL # SPECIES 3 TOTAL # SPECIMENS 30

AREA J SECTION 1 SAMPLE (& REPLICATE) NUMBER J-4 SAMPLING DATE 22 Jul 1978

DESCRIPTION AND NOTES approx. 550 m south of culverts (approx. 10 m south of sample J-3); scattered rocks, shells and mud on dense clay; surface area approx. 0.25 m^2

SPECIES		MOLLUSC SHELL LENGTH SIZE CLASSES (CM) 0.1-1.0	1.1-2.0	2.1-3.0	3.1-4.0	4.1-5.0	5.1-6.0	6.1-7.0	7.1-8.0	8.1-9.0	TOTAL #	# & % LARGE (≥3.8 CM)
Tapes japonica	#		15	61	26	21	3				126	36
	%		11.9	48.4	20.6	16.7	2.4					28.6
Mya arenaria	#	1	8								9	0
	%	11.1	88.9									00.0
Musculus senhousia	#		5	15							20	0
	%		25.0	75.0								00.0
Ascidiacea	#										1*	-
	%											-
	#											
	%											
	#											
	%											
	#											
	%											
	#											
	%											

TOTAL # SPECIES 4 TOTAL # SPECIMENS 156 * possible Molgula manhattensis

AREA J SECTION 3 SAMPLE (& REPLICATE) NUMBER J-5 SAMPLING DATE 22 Jul 1978

DESCRIPTION AND NOTES east of north end of Van Waters and Rogers, Inc. building; rocks, gravel and mud

SPECIES		MOLLUSC SHELL LENGTH SIZE CLASSES (CM)									TOTAL #	# & % LARGE (≥3.8 CM)
		0.1-1.0	1.1-2.0	2.1-3.0	3.1-4.0	4.1-5.0	5.1-6.0	6.1-7.0	7.1-8.0	8.1-9.0		
Tapes japonica	#		6	2		1					9	1
	%		66.7	22.2		11.1						11.1
Mya arenaria	#											
	%											
	#											
	%											
	#											
	%											
	#											
	%											
	#											
	%											
	#											
	%											

TOTAL # SPECIES 1 TOTAL # SPECIMENS 9

AREA J SECTION 3 SAMPLE (& REPLICATE) NUMBER J-6 SAMPLING DATE 22 Jul 1978

DESCRIPTION AND NOTES north side of small promontory midway along west shore of Lagoon; rocks and gravel in mud

SPECIES		MOLLUSC SHELL LENGTH SIZE CLASSES (CM)									TOTAL #	# & % LARGE (≥3.8 CM)
		0.1-1.0	1.1-2.0	2.1-3.0	3.1-4.0	4.1-5.0	5.1-6.0	6.1-7.0	7.1-8.0	8.1-9.0		
Tapes japonica	#		2	5	2	2					11	3
	%		18.2	45.5	18.2	18.2						27.3
Mya arenaria	#					2	1				3	3
	%					66.7	33.3					100.0
	#											
	%											
	#											
	%											
	#											
	%											
	#											
	%											
	#											
	%											

TOTAL # SPECIES 2 TOTAL # SPECIMENS 14

AREA J SECTION 3 SAMPLE (& REPLICATE) NUMBER J-7 SAMPLING DATE 22 Jul 1978

DESCRIPTION AND NOTES approx. 200 m south of northwest corner of Lagoon; rocks, gravel and mud; hand dug

SPECIES		MOLLUSC SHELL LENGTH SIZE CLASSES (CM) 0.1-1.0	1.1-2.0	2.1-3.0	3.1-4.0	4.1-5.0	5.1-6.0	6.1-7.0	7.1-8.0	8.1-9.0	TOTAL #	# & % LARGE (≥3.8 CM)
Tapes japonica	#		7	10	6	5					28	7
	%		25.0	35.7	21.4	17.9						25.0
Mya arenaria	#					1	1				2	2
	%					50.0	50.0					100.0
	#											
	%											
	#											
	%											
	#											
	%											
	#											
	%											
	#											
	%											
	#											
	%											

TOTAL # SPECIES 2 TOTAL # SPECIMENS 30

AREA J SECTION 4 SAMPLE (& REPLICATE) NUMBER J-8 SAMPLING DATE 22 Jul 1978

DESCRIPTION AND NOTES sample from mud flats along north side of channel draining into Lagoon from Brisbane; non-quantitative sample

SPECIES		MOLLUSC SHELL LENGTH SIZE CLASSES (CM) 0.1-1.0	1.1-2.0	2.1-3.0	3.1-4.0	4.1-5.0	5.1-6.0	6.1-7.0	7.1-8.0	8.1-9.0	TOTAL #	# & % LARGE (≥3.8 CM)
Tapes japonica	#											
	%											
Mya arenaria	#											
	%											
Macoma balthica	#				1						1	0
	%				-							-
	#											
	%											
	#											
	%											
	#											
	%											
	#											
	%											

TOTAL # SPECIES 1 TOTAL # SPECIMENS 1

AREA J SECTION 5 SAMPLE (& REPLICATE) NUMBER J-9 SAMPLING DATE 22 Jul 1978

DESCRIPTION AND NOTES midway between rockpile at center of north shore and next rockpile further west; mud under rocks, with dense clay beneath

SPECIES		MOLLUSC SHELL LENGTH SIZE CLASSES (CM) 0.1-1.0	1.1-2.0	2.1-3.0	3.1-4.0	4.1-5.0	5.1-6.0	6.1-7.0	7.1-8.0	8.1-9.0	TOTAL #	# & % LARGE (≥3.8 CM)
Tapes japonica	#		6	6	5	4	3				24	7
	%		25.0	25.0	20.8	16.7	12.5					29.2
Mya arenaria	#					3		2	1	1	7	7
	%					42.9		28.6	14.3	14.3		100.0
	#											
	%											
	#											
	%											
	#											
	%											
	#											
	%											
	#											
	%											
	#											
	%											

TOTAL # SPECIES 2 TOTAL # SPECIMENS 31

AREA J SECTION 5 SAMPLE (& REPLICATE) NUMBER J-10 SAMPLING DATE 22 Jul 1978

DESCRIPTION AND NOTES approx. 30 m west of northeat corner of Laqoon; mud under large rock, with dense clay beneath

SPECIES		MOLLUSC SHELL LENGTH SIZE CLASSES (CM) 0.1-1.0	1.1-2.0	2.1-3.0	3.1-4.0	4.1-5.0	5.1-6.0	6.1-7.0	7.1-8.0	8.1-9.0	TOTAL #	# & % LARGE (≥3.8 CM
Tapes japonica	#		3	4	4	5					16	6
	%		18.8	25.0	25.0	31.2						37.5
Mya arenaria	#				1				1	1	3	2
	%				33.3				33.3	33.3		66.7
Musculus senhousia	#			1							1	0
	%			100.0								00.0
Macoma nasuta	#		1								1	0
	%		100.0									00.0
	#											
	%											
	#											
	%											
	#											
	%											
	#											
	%											

TOTAL # SPECIES 4 TOTAL # SPECIMENS 21